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WEEKLY 10 September 2022

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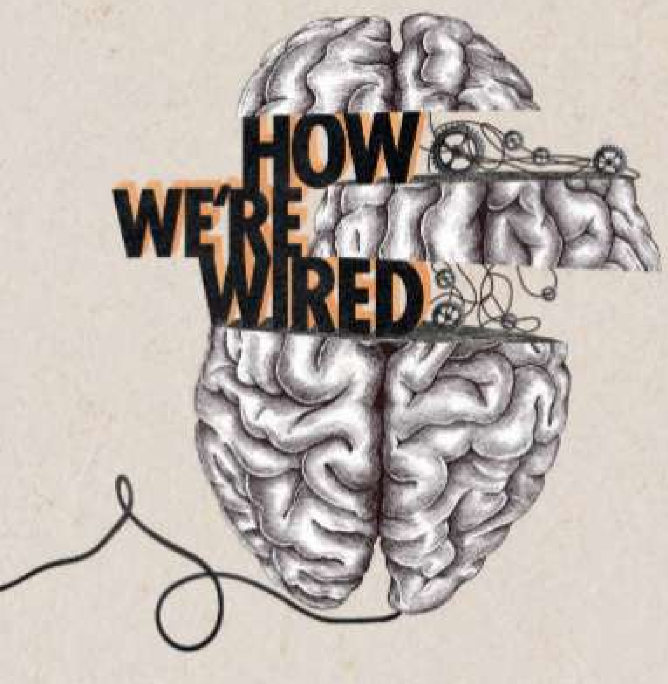

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Academy

Beyond Einstein: Making sense of general relativity and the ideas it inspired

Albert Einstein's greatest theory, which says that gravity is the product of mass warping space-time, transformed our picture of the universe. In this course, dive into general relativity and the many predictions it spawned, from black holes and the expanding universe to gravitational waves.

newscientist.com/academy

NS Live

Ultra-processed foods

In the UK, people get more than half their calories from ultra-processed foods, such as ready meals, breakfast cereals and sausages. Join us at New Scientist Live to hear Chris and Xand van Tulleken, stars of the BBC's *The Twinstitute*, reveal the truth about what these foods do to our bodies. NS Live is at ExCeL London from 7 to 9 October.

newscientistlive.com

Podcast

Weekly

The team discuss a new kind of bacteria, discovered deep inside Earth, that eat petroleum. They also look at the unusual evolutionary history of mucus and the many mammal species that rely on it. Plus, author Gaia Vince talks about the coming era of mass climate migration, in which millions of people will be forced to move countries – and what we need to do to prepare.

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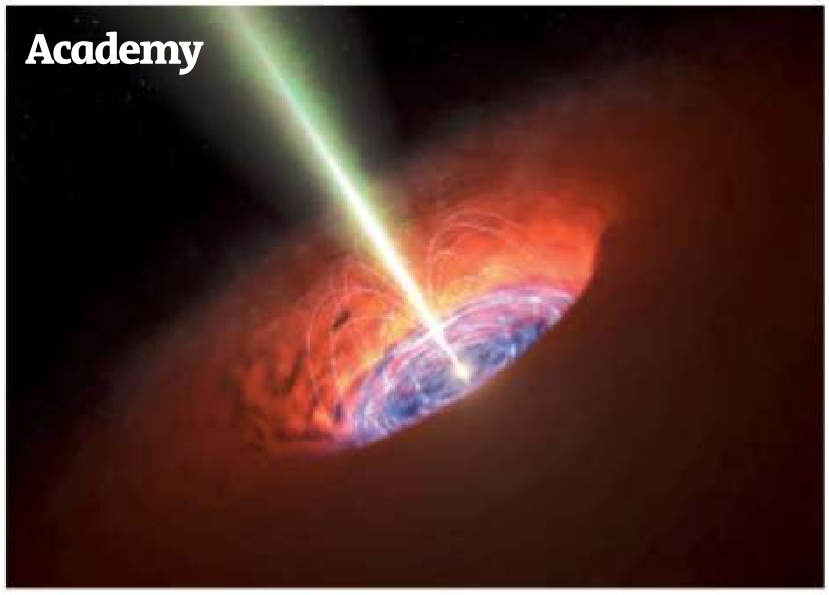

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Quasar quest Discover the spectacular secrets of black holes

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Nomad century Life in the age of mass climate migration

Video

Leaping "gearbot"

A gearbox driven by an external magnetic field can power tiny robots that crawl like a caterpillar or jump almost 40 times their own height, despite having no batteries or motors on board. This soft robot technology could lead to medical robots that can travel through the human body, taking samples or delivering drugs.

youtube.com/newscientist

Newsletter

Health Check

Ever been confused by advice about medical decisions, such as whether to take a new drug or undergo cancer screening? You aren't alone. Health reporter Clare Wilson talks about what to look for when considering the risks and benefits of things like hormone replacement therapy, statins and eating sausages.

newscientist.com/healthcheck

A note from the editor

Dear reader,

This is another shout out for New Scientist Live London, our flagship live event, which is due to take place at ExCeL London between 7 and 9 October. We very immodestly call it the world's greatest science show – because it is!

Friday is schools' day this year, so if you teach children who are passionate about science, tech and big ideas, do please get in touch; it's not too late to get a place for your class. There will be special programming to appeal to younger humans, including talks from Stefan Gates and Helen Czerski, as well as myriad interactive activities that will bring science to life.

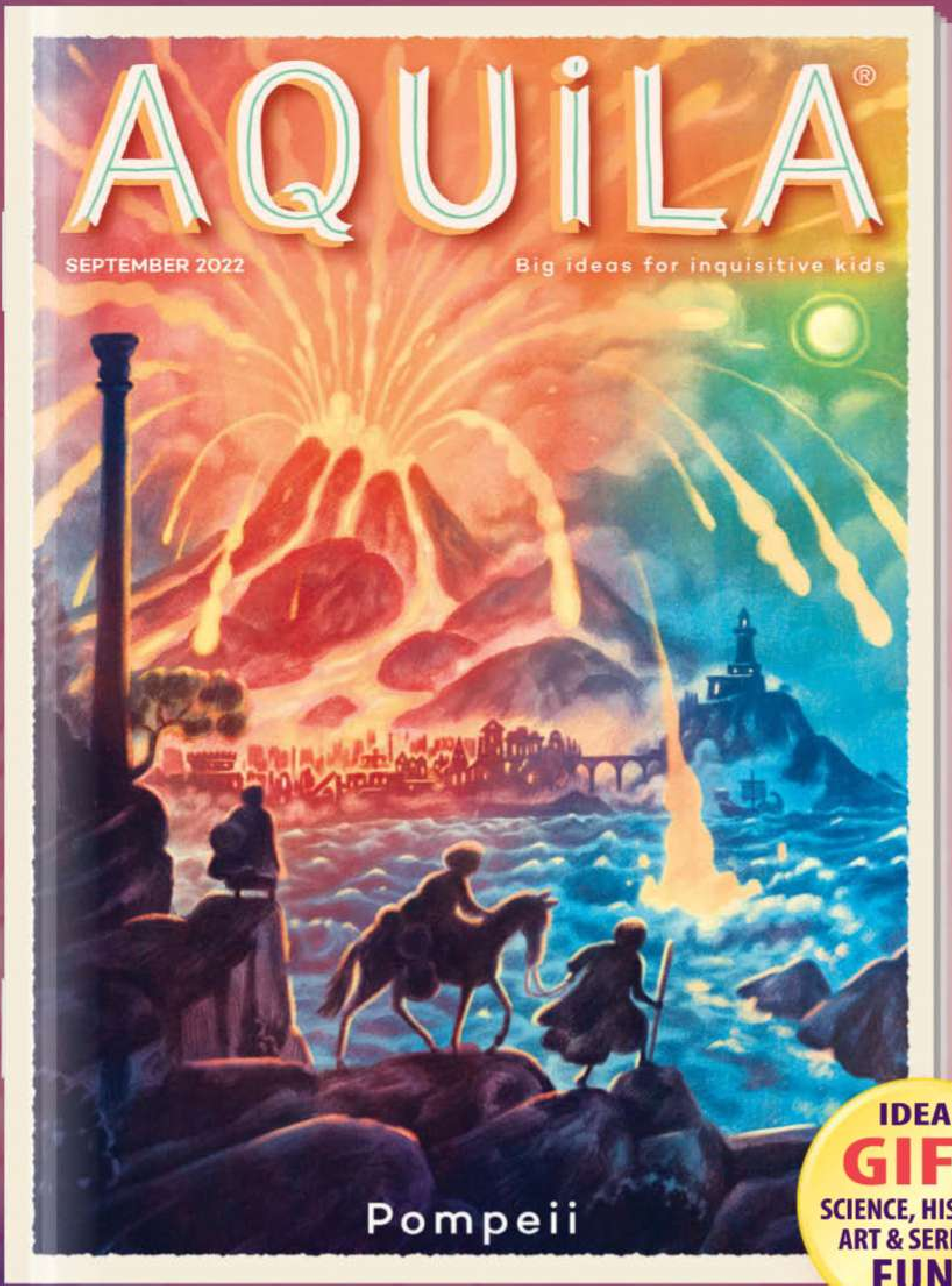
Saturday and Sunday will be for people of all ages to enjoy. Talks I am especially looking forward to include Turi King on DNA family secrets and the Van Tulleken twins, Chris and Xand, on ultra-processed foods (see left).

Do check out the full line-up at newscientistlive.com. By the way, the early bird discount for tickets ends on 11 September. You won't get a better deal as we get closer to the show.

I do hope to see you at ExCeL London, but if you can't make it in person, you can join us on our live stream or catch up with the talks on demand at a later date. All the details are on the website.

Emily Wilson
New Scientist editor-in-chief

AWARD-WINNING CHILDREN'S MAGAZINE



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Super cells

Quantum batteries are worth pursuing amid the climate emergency

YOU don't have to look hard to see that the world is in crisis. The terrible floods in Pakistan have made 33 million people the latest victims of the climate crisis. Meanwhile, in Europe, the surging cost of gas is causing some in the UK to panic-buy wood to heat their homes (see page 8).

These crises, though very different, have a common cause: our reliance on burning fossil fuels. Clearly, we need to make the transition to renewable sources of energy – and fast. We all know the challenges. If we are to get most of our power from renewables, we must find a way to manage the intermittency of wind and solar. To decarbonise transport, we need more people to buy electric vehicles. In both cases, better batteries are crucial.

Today's best batteries are made with lithium ions. But supplies of lithium are finite and the mining process can damage the environment. That is why battery researchers are looking beyond lithium towards all manner of alternatives.

Quantum batteries are one of the most unusual of these. Like quantum computers, these would be made up of qubits – quantum alternatives to classical bits – and they would offer an advantage thanks to a quantum property called entanglement. The key point is that the more qubits you have, the faster your battery will charge. In theory, a quantum battery made up of 100 qubits could charge 100 times faster than a classical battery of the same capacity, as we report in our cover story (see page 38).

> **"Batteries that charge instantly would be transformative for the transition to electric vehicles"**

It sounds too good to be true. But earlier this year, researchers showed for the first time that quantum batteries have this advantage in practice. That is a huge step, even if there is no guarantee that the technology can be scaled up. Some will scoff, arguing that practical quantum batteries are a pipe dream. But batteries that charge in an instant would be transformative, not least in terms of boosting the transition to electric vehicles, which is hampered by charging times that can be painfully slow. Given the promise of instant power, quantum batteries should be taken seriously. ▮

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JIM WATSON/AFP VIA GETTY IMAGES

A walk-in vaccination site in Washington DC

Coronavirus

Vaccines cut covid spread

Figures from US prisons show that vaccines and past infections reduce transmission of the omicron variant, reports **Clare Wilson**

PEOPLE who have been vaccinated against covid-19 and also had a previous infection have a 41 per cent lower risk of passing on the coronavirus if they become infected again, compared with someone who is unvaccinated and has had no past infections.

The finding comes from a study carried out in US prisons that looked at how often people passed on the virus to someone sharing their cell. It was done during the omicron wave.

The research rebuts the idea that the only reason to get vaccinated against covid-19 is to reduce your risk of getting seriously ill, says Simon Williams at Swansea University in the UK, who wasn't involved in the work. "It's a really important finding."

Vaccination against covid-19 markedly reduces the chance of dying from the disease or needing hospital treatment. But it is less clear how effective it is at stopping people from catching the virus and from spreading it to others. That is a key question, because people may consider getting vaccinated not just to benefit their own health, but to reduce their chance of passing it on, especially to more vulnerable relatives.

With the earlier coronavirus variants, it seemed that vaccines reduced infections and transmission by significant amounts – with estimates as high as 90 per cent for the Pfizer/BioNTech shot. But when the omicron variant started spreading globally in November 2021, it became apparent that vaccines were less effective at stopping people from catching the virus, although there was still protection against serious illness.

To investigate, Nathan Lo at the University of California, San Francisco, and his colleagues looked at the records of 35 prisons in California. They analysed transmission within cells with solid doors and walls, from December 2021 to May this year.

During this period, if a prisoner had covid-19 symptoms or tested positive, they were generally moved into isolation, but this didn't always happen straight away. From the jail records, the team found nearly 1300 prisoners who tested positive for covid-19 and shared a cell for at least one night with someone who had recently tested negative.

The prisoners who had tested negative spent an average of 2.3 days with an infected prisoner and more than a quarter of them caught the coronavirus.

The chance of passing on the virus was 21 per cent lower if the infected prisoner had had covid-19 before, compared with if they had no vaccine and no prior infection. It reduced by 24 per cent if they had had at least one dose of vaccine but no previous infection, and by 41 per cent if they had been infected previously and vaccinated.

Transmission risk fell by an additional 12 per cent for each dose of vaccine the infected prisoner had after the first, with some prisoners having had three shots.

"This study supports the importance of booster doses in reducing population-level transmission," the team writes (medRxiv, doi.org/jbj9).

"We need to put this message out there that vaccines work not just to reduce serious illness, but to reduce transmission," says Williams. The findings are relevant for the question of whether covid-19 booster shots should be offered widely, he says. Only certain groups are being offered boosters in the UK, while in the US, the Centers for Disease Control and Prevention recommends them for everyone aged 5 and up. ▮

New Scientist Live
How the immune system fights disease
Daniel Davis at New Scientist Live
newscientistlive.com

Environment

Energy crisis sparks firewood rush

People in the UK are buying up logs and installing wood-burning stoves to heat their homes amid spiralling gas prices, finds **Adam Vaughan**

MILTON COGHEIL/ALAMY

Greater use of wood-burning stoves will cause more air pollution in London

WOOD suppliers in the UK have reported an unprecedented surge in demand for logs, briquettes and other biomass products as households rush to minimise the impact of rapidly rising energy bills.

However, experts cautioned that a resurgence in burning wood in stoves, fires and boilers at home could exacerbate air pollution and damage people's health.

"What we're seeing is an absolute panic buy, like a covid emptying of the shelves of loo roll and pasta," says Marc Odin at MJO Forestry, which supplies wood to 15 retailers in the south-east of England.

In a normal August, he delivers some 55 cubic metres of wood; last month, he delivered about 250 m³. "It is all about the gas price," he says, referring to Ofgem, the energy regulator for England, Scotland and Wales, confirming on 26 August that its price cap for a unit of gas will rise from 7p to 15p from 1 October.

More than four-fifths of the UK's homes are heated by gas, while about a tenth also burn wood fuel. This coming winter, fires and stoves that burn wood look likely to be used more heavily than in recent years as people try to minimise central heating use.

"It's just absolutely unprecedented," says Rowland Parke at the Wood Fuel Co-operative in Dumfries, UK. He says the group sold as much wood from June to August as it would usually during three months in autumn and winter. Some of the 2000 customers that the co-op serves in the local area have told his team that they are going to use less gas and electricity and burn as much wood as they can.

Bruce Allen, chief executive of HETAS and Woodsure, groups that certify stove installations and quality wood, says "members are also seeing a higher demand for wood fuel with customers stocking up on wood earlier and taking bigger loads to avoid using their central heating as much". People also seem to be installing more wood-burning appliances than usual at this time of year, says Allen. Visits to the HETAS website were up 60 per cent in August.

> **"What we're seeing is an absolute panic buy, like a covid emptying of the shelves of loo roll"**

Mark Lebus at the UK Pellet Council, which is a trade body, says: "We are seeing considerable uptick in new wood burning stoves and small domestic biomass boilers as the price of wood pellets remains very competitive with gas, oil and especially electricity."

Other companies supplying biomass for homes report a leap in custom. "Demand for firewood is huge, with customers wanting to have an alternative heating source and fuel paid for ahead of winter," says one industry figure, who didn't want to be named.

Janis Reinsons at Lekto Woodfuels in the UK, which sources wood from Latvia, says the company "has been experiencing historically high demand this summer". The firm sold more wood fuel in August than in its usual peak month of December.

Reinsons is aware of competitors routinely running out of stock, and Odin says that two of the biggest retailers he supplies expect to run out of wood by December, if the current high demand continues.

Russia's invasion of Ukraine, the main reason for rising gas prices, is also shifting the provenance of wood burned in UK homes. Parke says one German supplier has hiked prices of beech exports to preserve the fuel for domestic use. Wood fuel imports from Russia and Belarus to the UK have been halted since the war began.

The UK government last month proposed suspending rules on the quality of wood pellets due to disrupted supplies.

Pollution risk

Growth in the number of wood-burning stoves has seen a 35 per cent increase in air pollution particles less than 2.5 micrometres in diameter, known as PM2.5, from domestic wood burning between 2010 and 2020. That has led to calls for a ban on sales of stoves in some quarters. Yet today's high gas prices look set to boost wood burning, and air pollution.

"It is important that vulnerable people are helped to keep warm this winter, but extra wood burning is not the answer," says Gary Fuller at Imperial College London. "It will worsen the existing air pollution problems in our cities, towns and even across the countryside." He says people also need to think about where wood is sourced from, because felling more trees will see woodlands release more carbon and could harm wildlife habitats.

Allen says it is important that people buy firewood with a moisture content of less than 20 per cent, which minimises particulate pollution. "If we are going to see an increase in wood burning as an alternative, then we want to ensure that it's being done in the most environmentally responsible way to safeguard the air we all breathe," he says. ■

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The science of exploding stars with Or Graur
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Astronomy

James Webb Space Telescope snaps its first exoplanet...

Alex Wilkins

THE James Webb Space Telescope (JWST) has captured its first direct images of an alien world – and as the telescope is performing better than expected, we are likely to see many more in the future.

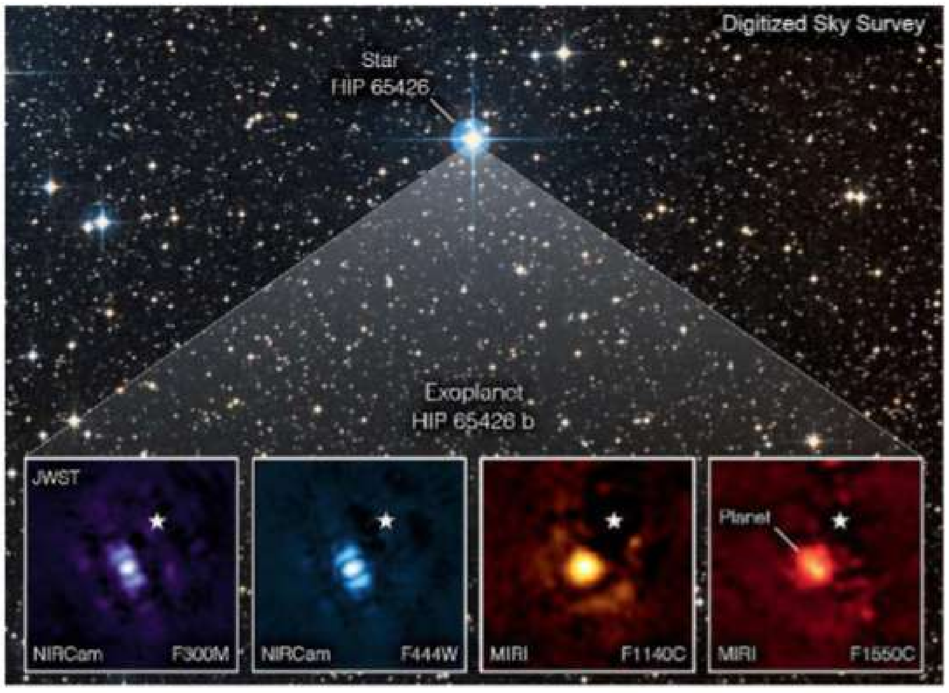
Astronomers have taken such images of just 20 exoplanets, all from Earth-based telescopes. But because our planet's atmosphere blocks out large parts of the infrared part of the spectrum, it has been hard to detect features of these planets in any great detail.

"Being here on Earth really sets a sensitivity floor to what we're able to detect, and to this day, the lowest mass planet we've been able to detect is about two Jupiter masses," says Sasha Hinkley at the University of Exeter, UK.

Now, Hinkley and his colleagues have used JWST to directly image a so-called super-Jupiter exoplanet, HIP 65426 b, which is around seven Jupiter masses and orbits a star around 400 light years from Earth. The team captured it in a range of infrared wavelengths and at a precision that had previously been impossible (arxiv.org/abs/2208.14990).

While this didn't extend the range of direct observations to smaller worlds, it was chosen to test JWST's capabilities because it had previously been viewed by ground-based telescopes. Future work with the space observatory should allow us to go further, says Hinkley. "It's going to allow us to get down to planets that are analogues of ice giants in our own solar system. These might be things like Saturns, or possibly even Neptunes if we're lucky."

Exoplanet HIP 65426 b as seen by the NIRCam and MIRI instruments



NASA/ESA/CSA, A CARTER (UCSC), ERS 1386 TEAM, A. PAGAN (STSCI)

HIP 65426 b is relatively young and hot, meaning it is easier to image. The team found that JWST performed 10 times better than expected and was much more sensitive than previous telescopes.

"We get just exquisite sensitivity with JWST, so we can see really faint objects, especially if they're a bit further from the star," says team member Beth Biller at the University of Edinburgh, UK.

Imaging HIP 65426 b is tricky because it orbits so close to its host star, which creates a high contrast in brightness. Hinkley and his team used a coronagraph to block out the star's light, allowing them to image the planet across a range of wavelengths. This distant world looks a little different depending on which of JWST's two infrared instruments, NIRCam and MIRI, were used because of the way these devices process the data, says Biller (see images, left).

Because JWST is in such demand to observe many different astronomical objects, it isn't actually the optimal exoplanet-imaging device, says Michael Merrifield at the University of Nottingham, UK. "But it's such a big leap forward on everything that, actually, I think it will probably take us into regimes we've never been to before."

That said, there are limits. Exoplanets are so far away from Earth and such difficult objects to image that even JWST can't capture high-resolution pictures that look like planets in our own solar system. ▮

...and sees strange sandy clouds on a brown dwarf

ASTRONOMERS have found direct evidence of clouds made from sand-like substances on a brown dwarf.

These large balls of gas, more massive than planets but without enough mass and pressure from gravity to start nuclear fusion like stars, glow mostly in the infrared range. To date, all our observations of these failed stars had been in a narrow wavelength of light, limiting our understanding of their chemical composition.

Now, Beth Biller at the University of Edinburgh, UK, and her colleagues have used the James Webb Space Telescope (JWST) to capture the signature of VHS 1256 b, a brown dwarf that is almost 20 times more massive than Jupiter and just under the threshold for nuclear fusion (arxiv.org/abs/2209.00620).

The telescope's ability to observe across a wide range of infrared means the team could capture much more detail from the brown dwarf's atmosphere, identifying molecules of water, methane and carbon dioxide; metals like sodium and potassium; and clouds made from silica-based particles, similar to sand. While astronomers had previously inferred the existence of silicate dust clouds in some brown dwarfs based on their colours, this is the first direct evidence of these clouds.

These silicates are probably molecules like enstatite and forsterite, which make up part of Earth's mantle. On VHS 1256 b, they instead take the form of tiny particulates floating through the atmosphere like smoke, says team member Sasha Hinkley at the University of Exeter, UK.

"If you put out your hand, you would feel sand, like when it is super windy at the beach"

"My mental picture is that, if you put out your hand, you would feel sand, like when it is super windy at the beach," says Mark Marley at the University of Arizona. "For us to see the feature in the spectrum means that at least some of the particles are small, sub-micron, so like very fine-grained dust, but some will be bigger, up to beach sand size." ▮

AW

Energy

Nuclear fusion advances as reactor fires up for 30 seconds

Matthew Sparkes

A NUCLEAR fusion reaction has lasted for 30 seconds at temperatures in excess of 100 million°C. While the duration and temperature alone aren't records, the simultaneous achievement of heat and stability brings us a step closer to a viable fusion reactor – as long as the technique used can be scaled up.

Yong-Su Na at Seoul National University in South Korea and his colleagues have succeeded in running a reaction at the extremely high temperatures that will be required for a viable reactor, and keeping the hot, ionised state of matter that is created within the device stable for 30 seconds.

Controlling this so-called plasma is vital. If it touches the walls of the reactor, it rapidly cools, stifling the reaction and causing significant damage to the chamber that holds it. Researchers normally use various shapes of magnetic fields to contain the plasma – some use an edge transport barrier (ETB), which sculpts plasma with a sharp cut-off in pressure near to the reactor wall, a state that stops heat and plasma escaping. Others use an internal transport barrier (ITB) that creates higher pressure nearer the centre of the plasma. But both can create instability.

Na's team used a modified ITB technique at the Korea Superconducting Tokamak Advanced Research (KSTAR) device, achieving a much lower plasma density. Their approach seems to boost temperatures at the core of the plasma and lower them at the edge, which will probably extend the lifespan of reactor components.

"The physics of fusion reactors is becoming well understood, but there are still technical hurdles"

Dominic Power at Imperial College London says that to increase the energy produced by a reactor, you can make plasma really hot, make it really dense or increase confinement time. "This team is finding that the density confinement is actually a bit lower than traditional operating modes, which is not necessarily a bad thing, because it's compensated for by higher temperatures in the core," he says.

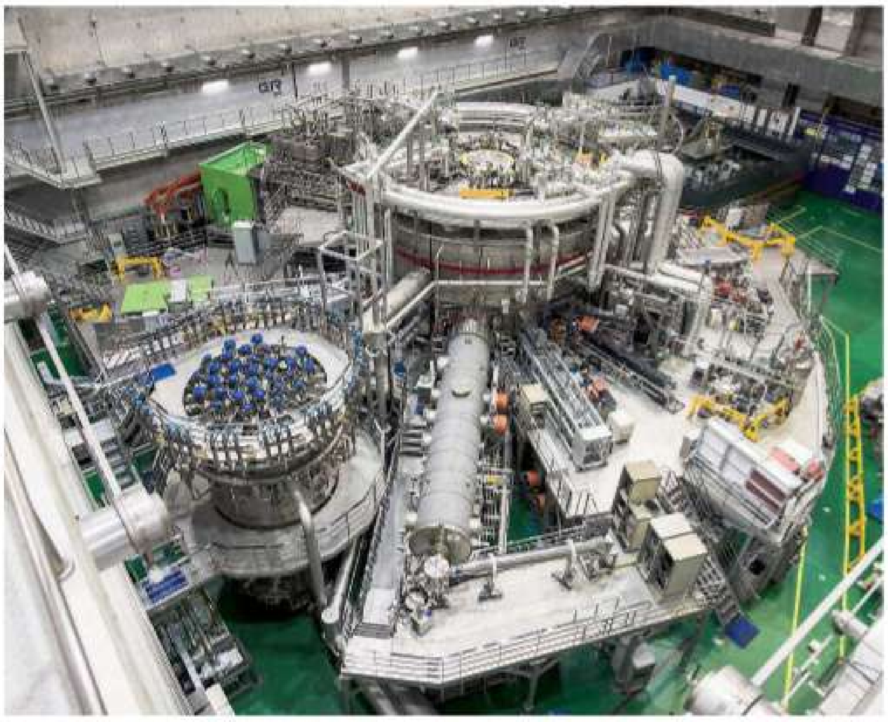
Na says that low density was key, and that "fast" or more energetic ions at the core of the plasma – so-called fast-ion-regulated enhancement – are integral to stability. But the team doesn't yet fully understand the mechanisms involved (*Nature*, DOI: 10.1038/s41586-022-05008-1).

The reaction was stopped after 30 seconds only because of limitations with hardware, and longer periods should be possible in future. KSTAR has now shut down for upgrades, with carbon components on the wall of the reactor being replaced with tungsten, which Na says will improve the reproducibility of experiments.

Lee Margetts at the University of Manchester, UK, says that the physics of fusion reactors is becoming well understood, but that there are technical hurdles to overcome before a working power plant can be built. Part of that will be developing methods to withdraw heat from the reactor and use it to generate electrical current.

"It's not physics, it's engineering," he says. "If you just think about this from the point of view of a gas-fired or a coal-fired power station, if you didn't have anything to take the heat away, then the people operating it would say 'we have to switch it off because it gets too hot and it will melt the power station', and that's exactly the situation here."

South Korea's KSTAR fusion reactor



KOREA INSTITUTE OF FUSION ENERGY

Material science

Lasers can make diamonds from simple plastic

Leah Crane

BLASTING plastic with powerful lasers can create tiny diamonds. Similar processes may occur at the high temperatures and pressures found within planets, which could help explain why Neptune is so strange.

Researchers have been able to create nanodiamonds before by shining lasers at a mixture of carbon and hydrogen, but it required extraordinarily high pressures. Siegfried Glenzer at SLAC National Accelerator Laboratory in California and his colleagues found that by using a simple plastic called PET – commonly used to make bottles and other containers – which is made up of carbon, hydrogen and oxygen, they could make diamonds in much less extreme conditions.

When they fired a powerful laser at the plastic, it heated up to temperatures between 3200°C and 5800°C and the shock waves generated by the laser pulse brought the plastic to pressures upwards of 72 gigapascals – equal to one-fifth the pressure in Earth's core. This separated the hydrogen and oxygen from the carbon, leaving behind tiny diamonds a few nanometres across and a form of water called superionic water, which conducts electricity more easily than regular water (*Science Advances*, doi.org/gqrbdt).

This happened at lower pressures than in previous experiments, says Glenzer. "What that means is that diamonds are probably everywhere," he says. "If it happens at lower pressures than previously seen, it means they're inside Uranus, inside Neptune, inside some moons such as Titan, which contain hydrocarbons."

This could explain why Neptune is unexpectedly hot, as diamonds forming in the planet's mantle and then sinking towards its core would generate friction and heat in the process.

Privacy flaws in US monitoring apps

Apps used by US authorities to track immigrants require "dangerous permissions"

Jeremy Hsu

AN ANALYSIS of monitoring apps installed on people's smartphones in the US as an alternative to incarceration found numerous privacy flaws. For instance, an app used to track a quarter of a million people with pending immigration cases required "dangerous permissions", as defined by the Android operating system, without mentioning it in its privacy policy.

Kentrell Owens at the University of Washington in Seattle and his colleagues analysed 16 Android smartphone apps used by federal and state authorities to track people awaiting immigration court dates, young people in juvenile detention systems and adults on parole or probation.

Seven of the apps appeared to violate the Google Play Store's user data policies by either linking to generic privacy policies or failing to link to any privacy policy at all.

> "We're seeing more and more people subjected to surveillance through apps on their phones"

Among them was BI SmartLINK, used by US Immigration and Customs Enforcement (ICE) to track undocumented immigrants who have been released from detention and are awaiting court dates to determine if they will be allowed to stay in the country. The number of people monitored through the app has grown from fewer than 6000 in September 2019 to almost 248,000 as of last month, according to statistics from ICE's Alternatives to Detention programme.

ICE requires users to check in daily or weekly on the app by taking a selfie that is processed through face-recognition technology. Like many electronic monitoring apps, SmartLINK requests what are considered "dangerous permissions" in the Android OS, such as accessing the camera, getting the device's precise location, making phone calls without the user's permission and recording audio. But that information was originally missing in the generic privacy policy linked to in SmartLINK's Google Play Store page from October 2021 through March 2022, says Owens.

SALWAN GEORGES/THE WASHINGTON POST VIA GETTY IMAGES

The US Immigration and Customs Enforcement headquarters

The app's developer, BI Incorporated, changed the link and updated the privacy policy after being contacted by Owens and his colleagues. "In 2021, BI launched a new bi.com website and the link was erroneously directed to the privacy policy for bi.com," says Monica Hook, a spokesperson for BI Incorporated.

Six apps, including SmartLINK, also communicated with unique internet domain names that could enable employers and school administrators with Wi-Fi network monitoring tools to figure out if any users of such apps are connected to the network. "BI complies with all applicable privacy requirements and is always working to improve our products and services," says Hook.

Two other apps connected to Facebook analytics and login services. This means that if someone logs into the app using their Facebook credentials, Facebook could learn that the person is using an electronic monitoring app. One of these apps, called Sprokit, was considered by the researchers to be potentially the most invasive of the surveyed apps and has been offered to at least 1000 non-violent, low-level offenders as an alternative to incarceration in places such as Los Angeles, San Francisco and Oakland, California; Atlanta, Georgia; Iowa and New York.

Sprokit even contained code that would allow Google and Facebook to display ads. "Advertisers may be profiting off people's coerced use of apps," says Owens. Sprokit didn't respond to *New Scientist*'s request for comment.

6000
US immigrants monitored by one app in September 2019

248,000
US immigrants monitored by the same app in August 2022

Cheap solution

SmartLINK users reported difficulties in completing their required check-ins with ICE. That puts people at greater risk of being re-detained, which statistically means a much higher risk of losing their immigration court case, says Julie Mao at Just Futures Law, a non-profit organisation based in Washington DC. BI Incorporated's parent company, the GEO Group, says that 88.4 per cent of SmartLINK check-ins were completed successfully over the past five years.

Electronic monitoring apps are making it easier and cheaper for government authorities to perform mass surveillance of immigrants and other vulnerable populations, says Saira Hussain at the Electronic Frontier Foundation, a non-profit digital rights group. The technology cost of monitoring a SmartLINK user is less than $1 a day, compared with $2.74 a day for an ankle monitor, according to ICE statistics.

"We're seeing more and more people who normally wouldn't be subjected to immigration detention or an ankle monitor now being subjected to surveillance as a result of how cheap and easy it is to install these apps on people's phones," says Hussain.

Owens and his colleagues presented the research at the USENIX Security Symposium held in Boston, Massachusetts, in August. ■

Environment

The Amazon rainforest has already reached a crucial tipping point

Luke Taylor

SO MUCH of the Amazon rainforest has been lost that it has reached a crucial tipping point – that would turn forest to savannah – earlier than expected, according to a report presented by Indigenous leaders from the nine countries and territories that encompass the Amazon region.

Vast swathes of the southern Amazon rainforest have gone and the rest will follow if deforestation isn't halted, the leaders told the fifth Summit of Indigenous Peoples in Lima, Peru, this week.

Researchers have predicted that once a certain amount of the Amazon rainforest is lost, it will no longer be able to hold the necessary moisture and generate the rainfall it needs to support itself. This would set off a chain reaction as the world's largest rainforest transforms into a savannah.

When this tipping point will occur is unclear, but 2018 work suggested it would be when about 20 to 25 per cent of the Amazon had been lost or highly degraded.

Surging deforestation in recent years means that threshold has now been passed, finds the latest report. It says that about 26 per cent of the Amazon has been cleared or highly degraded in about 35 years.

Marlene Quintanilla at the Amazon Geo-Referenced Socio-Environmental Information Network (RAISG) and her colleagues, working with various groups, including the Coordinator of Indigenous Organizations of the Amazon River Basin, used forest coverage data to map how much of the Amazon was lost between 1985 and 2020 and also looked at forest density, rainfall patterns and carbon storage.

A deforested part of the Amazon in the state of Para, Brazil

RAPHAEL ALVES/AFP VIA GETTY IMAGES

The rainforest's abilities to store carbon and regulate precipitation are indicators of its capacity to survive, says Quintanilla.

The report finds that 33 per cent of the Amazon remains pristine and 41 per cent of areas have low degradation and could restore themselves. But 20 per cent is lost entirely and 6 per cent is highly degraded and would need human support to be restored.

"The ecological response of the forest is changing and its resilience is being lost," says Quintanilla. "We are at a point of no return."

The transformation is already visible in Brazil and Bolivia, say the report's authors. In the past 20 years, rainfall in parts of the Bolivian Amazon has reduced by 17 per cent and the temperature has risen by 1.1°C. Areas of dense rainforest are becoming savannah and trees in the north of the country have stopped producing the fruits that Indigenous groups depend on to eat, says Quintanilla.

If agriculture, mining and other drivers of deforestation don't cease, that process will spread quickly to other countries, say the authors.

About 86 per cent of deforestation has occurred in areas outside national or Indigenous reserves, and given that 48 per cent of the Amazon remains unprotected by reserves, those areas will be lost unless they are given protection, say the researchers. ▮

Biology

Some screen use before bedtime may be OK after all

A BIT of screen time before bed might not actually damage the quality of your sleep too much.

Many studies have found that exposure to blue light, which is produced by laptop and smartphone screens, can make people less sleepy and affect the quality of their rest. This is because the blue light makes bodily systems block the hormone melatonin that usually makes you feel drowsy.

To investigate further, Christine Blume at the University of Basel in Switzerland and her colleagues wanted to test whether blue light that affects only intrinsically photosensitive retinal ganglion cells (ipRGCs) in the eyes would have any effect on subsequent sleep quality.

These eye cells are particularly sensitive to blue light and are thought to play a big role in setting the body's internal circadian rhythms, says Blume.

The researchers tested 29 people in a sleep lab with exposure to two types of light. One was made up of a high proportion of blue light, which would be picked up by the ipRGCs; the other had a lower proportion.

On one of the nights in the lab, participants were exposed to one type of light from a screen for an hour, ending 50 minutes before they typically went to sleep. A week later, they were exposed to the other.

To assess how melatonin levels changed, saliva samples were taken before and after sleep. The bluer light reduced levels of melatonin by about 14 per cent below the level seen with the other light, on average, but no effect was found on self-reported sleep quality (*Sleep*, doi.org/jbh8). "This study shows that exposure to bright light in the evening for a limited amount of time does not necessarily impact sleep," says Blume.

"Exposure to bright light in the evening for a limited amount of time doesn't necessarily impact sleep"

"What this paper speaks to is how complex the processes of sleep and wakefulness can be," says Hugh Selsick at University College London. The role of melatonin is well established, but it is only one of several factors involved, he says. ▮

Jason Arunn Murugesu

Health

Trans fats ban saved 1200 lives

A Danish ban on adding artificial trans fats to food has saved many lives, particularly in lower-income groups, finds **Alice Klein**

LUIS ALVAREZ/GETTY IMAGES

Trans fats can be found in baked goods and fried food

DENMARK'S world-leading ban on artificial trans fats in food has slashed the number of people dying from heart disease, particularly in disadvantaged groups.

"It's an excellent lesson showing that when governments put high standards in place around food, it can have a really important population health impact," says Gary Sacks at Deakin University in Melbourne, Australia.

Trans fats are mostly made by adding hydrogen to vegetable oils to make them solid. They became popular due to their low cost and long shelf life.

Their main uses have been in margarine and processed bakery goods, such as biscuits, cakes and pies. Trans fats are also often found in deep-fried fast foods because partially hydrogenated vegetable oil needs changing less regularly than other oils in deep fryers. Small amounts of trans fats also naturally occur in some meat and dairy products.

In 1993, a landmark study showed a link between diets high in trans fats and heart disease. Denmark was quick to respond. In 1994, its local margarine producers agreed to reduce trans fats in their products, and in 2003, the Danish government banned all foods containing more than trace amounts of artificial trans fats.

The country has since recorded one of the steepest drops in deaths from heart disease in Europe.

To find out how much of this was to do with cutting out artificial trans fats, Kirsten Bjoernsbo at Bispebjerg and Frederiksberg Hospital in Denmark and her colleagues analysed data on Danish mortality rates, dietary habits, other risk factors like smoking and the effects of healthcare advances over time.

They found that deaths from coronary heart disease in Denmark declined by 74 per cent between 1991 and 2007. About 11 per cent of this drop could be attributed to cutting out artificial trans fats, equating to around 1200 lives saved.

"Regulating food composition benefits the whole population, not just those with resources"

The most lives saved seem to be in lower-income groups, who were previously the biggest consumers of trans fats (*PLoS One*, doi.org/jbgd). "Regulating food composition tends to be more equitable than strategies like food labelling because it benefits the whole population, not just those who have the motivation and resources to make change," says Sacks.

Forcing food manufacturers to ditch cheap trans fats may have increased the price of some foods, but only those "like pies and pastries that you want people to eat less of anyway, so that's probably a good thing", says Peter Clifton at the University of South Australia.

Other countries have since followed Denmark's lead in banning artificial trans fats, including the US in 2018 and the rest of the European Union in 2021. Others, such as the UK and Australia, have encouraged voluntary phase-outs. The World Health Organization is trying to eliminate artificial trans fats from food by 2023.

"I think this demonstrates that you can achieve population-wide health benefits with regulation," says Sacks.

It would be harder to phase out things like sugar and salt that are important for taste, but governments could put limits on how much can be in foods to cut consumption, he says. ▮

Quantum physics

Quantum magnet is billions of times colder than space

Karmela Padavic-Callaghan

A QUANTUM magnet has been built that is only a billionth of a degree warmer than absolute zero.

A regular magnet repels or attracts magnetic objects depending on whether electrons inside it are in an "up" or a "down" quantum spin state, a property similar to having a north and south pole aligned in a particular direction. However, this isn't the only property that can be used to build a magnet.

Kaden Hazzard at Rice University in Texas and his colleagues used ytterbium atoms to make a magnet based on a spin-like property that has six options, each labelled with a colour. The researchers confined the atoms in a vacuum in a small metal and glass box, then used laser beams to cool them down. The push from the laser beam made the most energetic atoms release some energy, lowering the temperature.

They also used lasers to arrange the atoms in different configurations to produce the magnets. Some were one-dimensional like a wire, others were two-dimensional like a thin sheet of a material or three-dimensional like a piece of a crystal.

The atoms arranged in lines and sheets reached about 1.2 nanokelvin, more than 2 billion times colder than interstellar space. For the atoms in three-dimensional arrangements, the situation is so complex that the researchers are still figuring out the best way to measure the temperature (*Nature Physics*, doi.org/h96v).

The atoms in the experiment belong to a larger group called fermions, and they were "the coldest fermions in the universe", says Hazzard.

Physicists are interested in how atoms interact in exotic magnets like this because similar interactions may happen in high-temperature superconductors – materials that perfectly conduct electricity. ▮

Health

The unexplained rise in UK deaths

Since April, there have been 22,500 more deaths than expected in the UK, causing concern among health experts. **Jason Arunn Murugesu** investigates what could be behind the surge

THE UK has seen an unexplained surge in deaths in recent months, causing concern among the country's chief medical officers.

Many suggestions have been put forward for why there have been about 22,500 more deaths between April and August than would normally be expected, but there is little agreement so far on the cause.

A spokesperson for the UK government's Department of Health and Social Care, for example, says: "Analysis is ongoing, however early investigation suggests circulatory diseases and diabetes may be partly responsible for the majority of excess deaths."

But Adrian Boyle at the UK's Royal College of Emergency Medicine doesn't believe that conditions like this, potentially worsened by coronavirus lockdowns delaying routine appointments, are likely to be the cause. "It takes time to die from cancer, it takes time to die from heart failure," he says. "These are all things that may have got worse during lockdown, but I'm not sure that is going to be driving the sudden and precipitous increase that we've seen in deaths this year."

"The data suggest that it is very likely that something substantial is happening," says Michael Murphy at the London School of Economics.

Researchers are scrambling to figure out what is going on, with problems within the National Health Services (NHS), an ageing population, heatwaves and a resurgence of covid-19 all also being mooted as possible causes. The fear is that this trend could worsen in the winter when healthcare systems are typically under most pressure.

The increase in deaths has been seen across the UK. Between 2 April and 12 August in England and Wales, for example, 202,491 deaths were registered, according to the Office for National Statistics (ONS). This is 19,756 higher than the five-year average – about an 11 per cent increase (see graph, right). The sudden drop in recorded deaths at the start of June probably reflects the closure of registration offices during bank holidays, says the ONS.

LEON NEAL/GETTY IMAGES

The Covid Memorial Wall opposite the Houses of Parliament in London

Meanwhile, in Scotland, 23,009 deaths were registered between 4 April and 21 August, according to the National Records of Scotland, which is about 10 per cent higher than the five-year average of 20,854 deaths. In Northern Ireland, 5980 deaths were recorded between 2 April and 12 August, according to the Northern Ireland Statistics and Research Agency, when the five-year average is 5378 – about an 11 per cent increase.

That adds up to over 22,500 more deaths than expected across the UK. What could be behind these worrying figures? Several researchers told *New Scientist* that it is too early to say, but pointed to a range of possibilities.

Perhaps the most obvious is the coronavirus. The current five-year average mortality statistics from the various UK statistics agencies are calculated in the same way: averaging each week's death rates from 2016, 2017, 2018, 2019 and 2021, but excluding 2020 figures because of the uniquely high levels of death caused by covid-19 that year. Could the coronavirus again be pushing up death rates?

The virus has contributed to the excess deaths, according to the data: there were twice as many deaths involving covid-19 this summer than there were in summer 2021 in the UK. Deaths between the relevant dates in April and August numbered just under 13,000. This accounts for over half of the increase, but it still leaves more than 9500 unexplained deaths.

> "The data suggest that it is very likely that something substantial is happening"

Covid-19 might also play a role in some of these deaths. This summer has seen rising infection levels. In early June, about 990,000 people in the UK were infected with the virus – driven mainly by the BA.4 and BA.5 subvariants of omicron, and more than 1.7 million people were estimated to be infected with the virus in early August.

The number of covid-19 cases probably indirectly increased the number of deaths from other things too, says Murphy. Studies suggest that having covid-19 increases the mortality risk for other conditions. "It's highly likely that covid would be implicated to some extent," says Murphy.

High covid-19 caseloads also disrupt healthcare systems, although it is unclear whether any resultant rise in deaths would be observed yet, particularly for conditions that can progress over many years, such as cancer, diabetes and heart problems.

"Cancer screening effectively stopped for a few months [during lockdowns], the number of people being referred for tests dropped, and many tests and treatments

Hear Patrick Vallance talk about his role during the covid-19 pandemic at New Scientist Live on 9 October
newscientistlive.com

were delayed," says Michelle Ferguson at Cancer Research UK. "So, there will absolutely be knock-on effects, we just don't know the scale yet."

A study published in June estimated that 460 extra people would die from bowel cancer in Australia between 2020 and 2044 due to healthcare system disruption caused by the pandemic and 437 would die earlier than expected. The picture is likely to be similar elsewhere.

"There is a reason for having treatment time targets for cancers – the delays matter," says Simon Wood at the University of Edinburgh, UK.

The pandemic has also led to a backlog in routine diabetes care and many people with the condition haven't had vital health checks for two years, says a spokesperson at the charity Diabetes UK. More than 700 people with diabetes die prematurely in the UK each week, according to the charity.

"It is important the government investigates this issue, particularly the question of whether delays in treatment are contributing to excess deaths," says Azeem Majeed at Imperial College London.

Other issues in the health services could also be causing problems. Some of the unexpected deaths could be the effects of longer-term NHS management issues starting to become apparent, says Michael Marmot at University College London.

Since 2010, the health services have lost almost 25,000 hospital beds across the UK, according to the Royal College of Emergency Medicine. The UK also has fewer beds per 1000 inhabitants than 21 EU nations, says the college.

The health services also face a staffing crisis. Research by UK health think tank Nuffield Trust suggests that NHS England, for example, is short of 12,000 hospital doctors and more than 50,000 nurses and midwives. The 2021 NHS staff survey in England found that just 27 per cent of staff say there are enough people in the organisation for work to be carried out effectively.

TOM PILSTON/PANOS PICTURES

A nurse working at University College Hospital in London

This has led to rises in waiting times for emergency care and ambulance responses. Ambulances have been held up in hospitals because they can't transfer patients into emergency departments that have reached full capacity, says Boyle. "We know that the time it takes for an ambulance to reach someone in cardiac arrest affects their chance of survival," he says.

"This is a chronic problem that's been allowed to keep building up," says Marmot. "We then had the pandemic and now we have the cost-of-living crisis, which is only going to drive health inequalities."

"It's reached a tipping point," says Boyle.

NHS problems aren't the end of the list of possible causes for the rise in deaths. Another contributor could be ageing. The median age of the UK population in 2001 was 37.9, but by 2020 it had risen to 40.4 years. The country's population is also growing. In 2015, the population was about 65 million, whereas in 2019 – before the pandemic – it was estimated to be 66.8 million. Even without the pandemic, the ONS had predicted that more deaths would have been registered in 2022 than in previous years because of these factors.

In England, most deaths between 2 April and 5 August have been in people aged over 85. More than 70,000 people above the age of 85 died in this period as did some 19,200 people who were between the ages of 50 and 64. Both age groups have seen an 11 per cent rise in deaths compared with a five-year average, which is more than 63,000 in the over 85s and more than 17,000 among 50 to 64-year-olds. More than 81,000 people aged between 65 and 84 died in this period, about 8.5 per cent higher than the average.

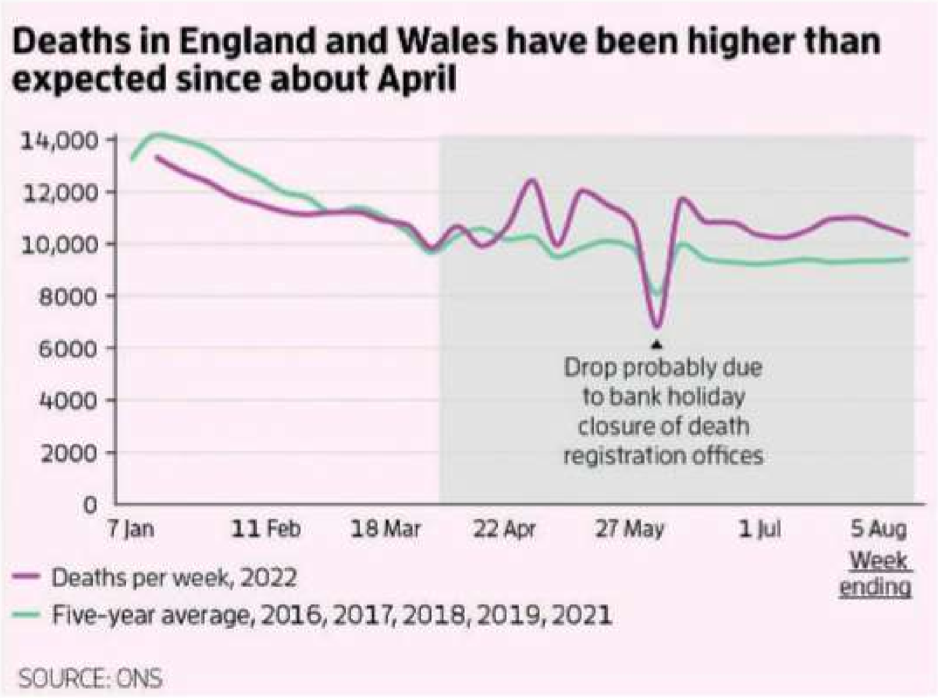
More deaths in older age groups were to be expected, but this doesn't explain all the extra fatalities, says Majeed.

One factor that would have particularly affected older age groups was the unprecedented heatwave that hit the UK in July, when temperatures peaked at a record 40.3°C (104.5°F).

Studies show that heatwaves are linked to higher rates of death from cardiovascular and respiratory conditions. Determining how many deaths are caused by heat is difficult, though, because many will be due to underlying health conditions exacerbated by temperature stress.

Antonio Gasparrini at the London School of Hygiene & Tropical Medicine has estimated that 948 extra people died between 17 and 19 July in England and Wales, when temperatures were highest during the heatwave, and most likely to lead to deaths. But large as this number is, it would cover only about 12 per cent of the non-covid-19 deaths within the April to August period.

The ONS is scheduled to release a report into the deaths this month. We may never know for sure what is causing the increase, but that doesn't mean efforts to halt it have to wait. The solution to most of these problems is to stop underinvesting in the heath services, says Boyle. ■


Deaths in England and Wales have been higher than expected since about April

SOURCE: ONS

Particle physics

Climate impact of 'Higgs factory' colliders ranked

Alex Wilkins

POLAR MEDIA/CERN

Artist's impression of the Future Circular Collider at CERN

PHYSICISTS planning to build the successor to the Large Hadron Collider (LHC) have started looking at the climate impact of a massive particle smasher, with plans to make it as energy efficient as possible.

The LHC, at the CERN particle physics lab in Switzerland, discovered the Higgs boson, a particle that gives mass to all the others. Now, physicists want to study it in more detail with a new kind of collider, known as a Higgs factory, which would produce large numbers of the particle by smashing together electrons and their antiparticles, positrons.

A Higgs factory would use a lot of energy, so Patrick Janot at CERN and Alain Blondel at the University of Geneva, also in Switzerland, have compared the carbon footprint of five of the most popular designs for such a collider to see which might have the least environmental impact.

"In our times of measurable climate change due to a global warming of unprecedented proportions, resulting from the emission of greenhouse gases, the most important criterion is that the scientific outcome for a given carbon footprint be maximised," says Janot.

The pair calculated the energy required per Higgs boson created for each collider design and found that the most energy hungry proposal, the Cool Copper Collider (CCC) in the US, would consume 18 megawatt-hours (MWh) per Higgs over a year.

> "The scientific outcome of a particle collider for a given carbon footprint should be maximised"

By contrast, the proposed Future Circular Collider (FCC) at CERN would use only 3 MWh per Higgs, and this could be reduced to 1.8 MWh with some upgrades to the design, a tenth that of the CCC. This proposed collider in Switzerland could also benefit from the carbon-free nuclear power produced in nearby France, unlike other designs, the researchers add (arxiv.org/abs/2208.10466).

Evaluating new collider designs in this way is a good idea, says Veronique Boisvert at Royal Holloway, University of London. "Benchmarks such as energy or emissions per Higgs boson, or some other physics-motivated criteria, are more relevant than, say, the energy or emissions used by the facilities per year," she says.

But the pair fail to take into account some other significant sources of carbon, says Boisvert, such as gases that are used in the detectors or concrete used to build the facility's tunnels, which can vary between designs. Janot and Blondel say they plan to update the work to address emissions associated with concrete production.

Uncertainties in predicting future carbon emissions based on countries' current electricity supplies also muddy the waters, says Kristin Lohwasser at the University of Sheffield, UK. Many places that could have Higgs factories, such as the US and China, will probably be using more renewable energy by the time such a facility might get built in the 2030s or 2040s, which would undermine some of the pair's arguments around France's nuclear power.

The proposed design upgrades to the FCC could also be applied to other colliders, such as the Circular Electron Positron Collider (CEPC) proposal in China, says Lohwasser, but the researchers didn't consider this in their analysis of the CEPC. "Climate considerations have consistently climbed up the list of things that need to be considered," says Lohwasser. ■

Cyberwar

Pro-Ukraine hackers achieved little after Russian invasion

Chris Stokel-Walker

UKRAINE'S "hacktivist" army abandoned cyber offensives against Russia just weeks after the war began, a new analysis has revealed.

Anh Vu at the University of Cambridge and his colleagues analysed how many cyberattacks were launched against Russian and Ukrainian targets in the first half of 2022 to examine the evolution of the cyberwar between the nations.

The researchers used global databases tracking the number of websites defaced by hackers and how many distributed denial of service (DDoS) attacks were launched. Tracking the data in advance of Russia's invasion of Ukraine on 24 February allowed them to see the impact it had on the number of cyberattacks launched against each country.

The day before the invasion, defacement attacks against Russian websites accounted for 0.75 per cent of all defacement attacks recorded online that day. On the day of the invasion, this leapt to more than 15 per cent of all attacks. DDoS attacks against Russian targets began to spike six days after the invasion, continuing at roughly that level for three weeks (arxiv.org/abs/2208.10629).

But after this point, DDoS attacks returned to a similar level to the pre-invasion baseline. The number of defacement attacks went back to normal even more quickly: two weeks after the huge spike in attacks, the number had returned largely to pre-invasion levels.

In their paper, the researchers write that the defacements were like "breaking into a disused shopping centre on the outskirts of a mid-sized Russian city and spraypainting 'Putin Sux' on the walls". They added: "These are trivial acts of solidarity, teenage competition, and expressive delinquency, not a contribution to the armed conflict in any real sense." ■

Welcome to our Signal Boost project – a page for charitable organisations to get their message out to a global audience, free of charge. Today, a message from **Veterinary Voices UK**

Veterinary Voices Hiking Group – Lets walk and talk

VETLIFE- A LIFELINE FOR THE VETERINARY PROFESSION

The veterinary professionals are disproportionally affected by mental health issues. Anxiety, burn out, compassion fatigue, loneliness and depression are high with a suicide rate four times that of the general public. Increased stressors were noted during the Covid 19 pandemic, many people have been split from their family and friends for a prolonged period of time causing isolation and loneliness. They also continued to work to provide emergency veterinary care under intense and often stressful working conditions.

Being a veterinary professional often brings a unique set of stressors and emotional burdens. Consequently, services provided by the charity Vetlife are essential: it's imperative we continue to raise awareness and support the charities work.

Therefore, each small action within the profession to help, support and alleviate pressures is a step forward.

WHY A HIKING GROUP?

The Veterinary Voices Hiking Group was set up by registered veterinary nurse Robyn Lowe and co-founders and veterinary surgeons Paul Horwood and Danny Chambers.

The team at Veterinary Voices UK have unique insight into the profession. Running multiple platforms with over 16 thousand Royal College of Veterinary Surgeons (RCVS) professionals (as well as student groups) where people are able to express their feelings and seek support from the collective community.

Although this initiative cannot fix all factors burdening the profession, of which there are many that influence these sad statistics, one thing that can bring about support and community is a community group, and so the Veterinary Voices Hiking Group was born!

The aims are to get the profession exercising, meeting up for local walks, forging connections, friendships and support systems in the local area and across the UK via our Facebook group. These aims help alleviate loneliness and strengthen support systems for people who are experiencing mental health burdens so they literally and metaphorically do not need to walk that journey alone.

Want to help?

You can help the Veterinary Voices Hiking Group by supporting their fundraising initiatives at www.justgiving.com/team/TeamVeterinaryVoices. The group is looking for sponsorship for upcoming events and challenges they are completing such as walking the Herriot Way. Please contact veterinaryvoicesuk@gmail.com if you wish to support us via sponsorship.

Do you need your signal boosted?

If you are a charitable organisation working in STEM, science, medicine, technology or conservation, and would like to find out more about this project contact Jacqui McCarron on jacqui.mccarron@newscientist.com

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Artificial intelligence

Meta AI can tell which words you hear by reading your brainwaves

Matthew Sparkes

AN ARTIFICIAL intelligence developed by Facebook's owner Meta can scan a person's brainwaves to "hear" what someone is saying to them. The software is of limited practical use for now, but could be a stepping stone to reading a nonverbal person's thoughts to allow them to better communicate – though Meta has no immediate plans to turn it into a commercial product.

Jean-Rémi King at Meta and his colleagues used existing data sets of brainwaves taken from 169 people as they listened to recordings of others speaking – the recordings were mostly existing audiobooks. The team split the data into chunks of 3 seconds and fed both the brainwaves and the sound files to an AI, which learned to spot patterns between the two.

The researchers held back 10 per cent of the data for testing, giving AI brainwave data that it had never had before in order to determine its ability to work out what was being said from just this.

They found that it was able to deduce which individual words, from a vocabulary of 793, the person was hearing at the time – at least to an extent. For each recording, the AI predicted a list of 10 words, and 73 per cent of the time this list included the correct word (arxiv.org/abs/2208.12266).

Thomas Knopfel at Imperial College London says that more refinement would be needed before such a system was accurate enough to be useful. He also questions whether the type of brain scans the team used – magnetoencephalography and electroencephalography, which are both non-invasive – could ever provide enough detail about the state of the brain to increase accuracy.

"It's about information flow," he says. "It's like trying to stream an HD movie over old-fashioned analogue telephone modems. Even in ideal conditions, with someone sitting in a dark room with headphones on, just listening, there are other things going on in the brain. In the real world it becomes totally impossible."

"The next step is to try to interpret a person's thoughts and allow them to communicate"

King says that the research goes one step further than similar previous work training an AI to identify which word a person was thinking of, or song they were listening to, from a small group of options. He says that determining what words a person is hearing is of limited use, and that the next step for his team is to try to interpret a person's thoughts and allow them to communicate.

"I think the next step is going to be language production. We're not decoding thoughts at this stage," he says. "I mean, we don't have any clue whether this is possible or not. But given how hard it is to record even something as crisp as the sound that you hear, language production, I think it's going to be even harder."

King says that the work was carried out by the company's scientific arm, Meta AI, which publicly releases general machine-learning research for use by other researchers and has no obligation to create practical applications. "We're not trying to build any product at this stage," he says. "Now, whether there will be applications of that research, I think it's possible, but it's also a bit more distant." ▮

Pollution

Unsafe mercury levels found in Amazon fish

MERCURY pollution from illegal mining in the Brazilian Amazon means many fish that people depend on for food in the state of Roraima are now unsafe to eat.

The toxic metal mercury is used to separate gold from sediment. An estimated 45 per cent of that used by illegal miners in the Amazon is dumped in rivers.

To determine the health risk, Ana Claudia Santiago de Vasconcellos at the Oswaldo Cruz Foundation in Rio de Janeiro, Brazil, and her team measured mercury levels in 75 fish at four locations on the Branco river, one of Roraima's major waterways.

At three of the four points, around half of all fish had mercury levels deemed unsafe by the World Health Organization. At the fourth location in Boa Vista, the capital of Roraima, 25.5 per cent of fish had unsafe levels (*Toxics*, doi.org/10/h953).

"The study shows that people in cities are now also at a high risk of getting sick from consuming mercury in fish," says study author Ciro Campos at Instituto Socioambiental, a Brazilian NGO.

"There is no safe amount of fish consumption for all the groups analysed, considering their diet of several types of fish, except for men who consume less than 50 grams [of fish] a day," says Vasconcellos.

PULSAR IMAGENS/ALAMY

Fish are a key food for Indigenous people like the Yanomami in Brazil

Mercury poisoning is particularly dangerous in pregnancy, as it is linked to a higher risk of miscarriage and developmental issues.

There is growing evidence it is causing neurological disorders in Amazonian peoples, particularly learning disabilities in children and visual and motor issues.

An illegal mining boom in Brazil is a public health crisis, says Campos. Between October 2018 and December 2021, the area destroyed by mining in the territory of one of Roraima's main Indigenous people, the Yanomami, more than doubled, according to Instituto Socioambiental. ▮

Luke Taylor

Climate change

Most major carbon capture and storage projects haven't met targets

Adam Vaughan

SEVERAL of the world's biggest projects capturing and storing carbon dioxide are significantly underperforming, according to an analysis showing some are capturing only half as much CO_2 as promised.

Carbon capture and storage (CCS) is seen as a vital tool for tackling climate change. A report by the Institute for Energy Economics and Financial Analysis (IEEFA), an Australian think tank, analysed 13 flagship existing CCS schemes worldwide, which together represent 55 per cent of captured CO_2, using figures published by the companies.

Most have captured less CO_2 than expected. Across its lifetime, the report says ExxonMobil's LaBarge facility at Shute Creek in Wyoming has underperformed by around 36 per cent in terms of capacity. The world's only large power station with CCS, Boundary Dam in Saskatchewan, Canada, has captured about 50 per cent less than planned, according to the report, and the capacity of Chevron's Gorgon gas scheme in Western Australia has been about 50 per cent lower than planned in its first five years. Two projects in the report failed entirely.

"Is CCS a solution to our climate woes? I would say no. More often than not, it doesn't actually work to its design capacity," says Bruce Robertson at the IEEFA.

The technology dates back to the 1970s, and in many cases is used to extract more oil from reservoirs rather than for curbing climate change by capturing CO_2 for the long term. "They [the industry] say it's an emerging sector. In actual fact, it has been in operation for most of our lifetimes," says Robertson. Underperformance isn't for want of financial or engineering resource, he adds. The Gorgon project alone cost AU$3.1 billion.

CCS facility at the Boundary Dam in Saskatchewan, Canada

MICHAEL BELL/THE CANADIAN PRESS/ALAMY

On a more positive note, the report finds that the Sleipner and Snøhvit CCS projects in Norway have been a success, which it says is largely due to the country's unique business and regulatory environment. Robertson says there may be a future role for CCS in heavy industries where emissions are hard to prevent, such as cement making.

Stuart Haszeldine at the University of Edinburgh in the UK says the IEEFA report is thorough, but that it is "too simple" to claim that CCS doesn't work. He says one reason CCS projects appear to be underperforming is a lack of market incentives for storing CO_2, and an absence of good regulation. "CCS does and will work when the rules are correct," says Haszeldine.

A spokesperson for Chevron says: "Innovation on this scale is not without its challenges, but the technology works." An ExxonMobil spokesperson says: "The LaBarge facility has captured more CO_2 than any other facility in the world to date." SaskPower, Boundary Dam's operator, disputed the suggestion that the project had a capture rate of about 50 per cent, giving a figure of 68 per cent. Robertson says this discrepancy is due to the IEEFA assessing the project's original target, rather than a revised, lower target. ▮

Health

Compression socks may cut runners' stomach problems

WEARING compression socks may reduce the intestinal damage thought to cause stomach issues in some endurance runners.

During intense exercise, some people experience "runner's stomach", a sudden onset of symptoms that can include nausea, cramping and the urgent need to use the toilet. Previous research suggested the symptoms may in part be caused by blood being redirected from the intestines to the leg muscles when running.

"That means places that don't get as much blood flow have a lack of oxygen and nutrients, so the cells in those areas can become damaged," says Kate Edwards at the University of Tasmania in Australia.

To test whether compression socks might help, by limiting blood pooling in the legs and improving blood flow to the trunk, Edwards and her colleagues recruited 46 adults running in the 2016 Gold Coast Marathon in Australia.

Half the runners wore knee-high compression socks from the morning of the marathon until they finished the race; the other half didn't. The researchers collected blood samples from everyone 24 hours before the marathon and again after they finished. They measured the level of a protein called intestinal fatty acid-binding protein, which is released when the intestinal lining becomes damaged.

There was little difference in levels of this protein between the groups before the race. Afterwards, however, levels had increased by 107 per cent on average in the control group, and by just 38 per cent in the group that wore the socks (*The Journal of Strength and Conditioning Research*, doi.org/h96j). That suggests the socks could reduce intestinal damage by maintaining blood flow to the gut.

"Places that don't get as much blood have a lack of oxygen and nutrients so can become damaged"

However, the study didn't actually measure whether the socks did improve blood flow, says Robert Maschi at Drexel University in Pennsylvania. "But there's no harm in using them," he says. ▮

Grace Wade

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Space exploration

Breathable oxygen pulled from Mars air

NASA's attempt to produce oxygen on Mars managed to generate about 100 minutes' worth of breathable oxygen in 2021. The technology is set to be scaled up to support human exploration.

The Mars Oxygen In-Situ Resource Utilization Experiment (MOXIE) is a small oxygen-generating set-up atop the Perseverance rover, which landed in February 2021. It works by pulling oxygen atoms from carbon dioxide in the Martian air.

Over seven hour-long runs, MOXIE was able to reliably make roughly 15 minutes of oxygen per hour in various conditions. That added up to a total of 50 grams of oxygen in total – which would be about 100 minutes' worth of breathable oxygen for a single astronaut (*Science Advances*, doi.org/gqqzpr). **Jacklin Kwan**

Technology

DeepMind trains soccer-playing AI

ARTIFICIAL intelligence has learned to play soccer. By learning from computer simulations, an AI took digital humanoids from flailing tots to proficient players.

Researchers at AI research firm DeepMind taught the system how to play in a computer simulation using an athletic curriculum resembling a sped-up version of a human baby growing into a soccer player. The AI controlled digital humanoids with realistic body masses and joint movements.

Teamwork skills, such as anticipating where to receive a pass, emerged over the course of about 20 to 30 simulated years of matches. This saw improvements in the digital humanoids' off-ball scoring opportunity ratings, a real-world measure of how often a player gets in a favourable position on the pitch (*Science Robotics*, doi.org/gqq56j). **Jeremy Hsu**

G. FUNSTON

Palaeontology

Mammals lived the fast life to size up after dinos

LARGER mammal species emerged rapidly after the extinction of the dinosaurs 66 million years ago, by living fast and dying young.

Prior to this, the largest mammal was about the size of a pet cat. Four million years later, which is quick in evolutionary terms, mammals such as the herbivorous *Pantolambda* were about the size of sheep. Just what spurred this change had been unclear, but now new clues locked in fossil teeth (pictured) suggest a fast lifestyle helped *Pantolambda* evolve bigger bodies.

These animals didn't look quite like any mammal alive today. They belonged to an extinct group called pantodonts that thrived 62 million years ago. Gregory Funston at the University of Edinburgh, UK, and his team have found that *Pantolambda* young spent seven months in the uterus and were weaned quickly, before growing rapidly until they perished at around 10 years of age.

Critical clues came from fossilised *Pantolambda* teeth. Mammal teeth chemically record specific moments in life, such as when the animal was born or stopped suckling. By looking at these clues, the researchers were able to outline the life of this previously enigmatic mammal.

Overall, their development was most similar to that of modern placental mammals that carry their offspring for a long time and wean them quickly. But *Pantolambda* also seemed to perish earlier than expected for creatures of its size, having what the team called a "fast" life history (*Nature*, doi.org/gqq5sg). "Giving birth to well-developed young gives them the best shot at survival, and maturing fast means as many young as possible get a chance to reproduce," says Funston. **Riley Black**

Really brief

UNCOMBABLE_LOCKS/INSTAGRAM

A genetic cause of uncombable hair

Another genetic cause has been found for uncombable hair syndrome, which makes frizzy blond hair stick out at right angles to the scalp. The wild hair has been linked to mutations in the *PADI3* gene, which encodes an enzyme that helps produce a hair protein (*JAMA Dermatology*, doi.org/h94k).

Whale songs spread across the Pacific

Humpback whale songs first heard off Australia have been recorded near Ecuador, suggesting that the noises passed between groups across the South Pacific Ocean. These songs may travel when pods of whales pass within an acoustic range of each other (*Royal Society Open Science*, doi.org/gqqx6h).

Crab-shell batteries that can degrade

A rechargeable battery made from crab shells and zinc could store energy, and then biodegrade or be recycled at the end of its life. The key is chitosan, a compound derived from chitin, a substance in crab shells. The chitosan stops the zinc corroding, making the battery more efficient (*Matter*, doi.org/gqq5q3).

AN IMPORTANT MESSAGE FROM PROFESSOR NICK LEMOINE CBE MD PHD FMEDSCI, CHAIR OF THE MEDICAL RESEARCH FOUNDATION

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"The funding I received through the Medical Research Foundation will be transformative for my research." Dr Myrsini Kaforou

While we don't know what the future holds for human health in the UK, we do know that research, and the brilliant scientists driving that research forward, are the key to meeting those challenges for years to come.

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Comment

Planning ahead

A dystopian future isn't inevitable. We should be doing all we can to leave a better world for generations to come, says **William MacAskill**

SIMONE ROTELLA

CURRENTLY, society does little to care for its future. In my new book, *What We Owe the Future*, I make the case for longtermism: the view that we should be doing much more to protect the interests of generations to come. Longtermism puts the needs of our children and grandchildren front and centre in our moral thinking, and takes seriously the sheer scale of the future that may be ahead of us.

Why should we look so far ahead? The case for longtermism is grounded in three key ideas.

The first is that future people matter. The moral worth of someone's life isn't diminished merely by being born 100 years from now. Imagine that, while hiking, I drop a glass bottle on the trail. If I don't clear it up, a child will cut herself badly on the glass shards. Should I care less about her pain if that child happens to step on the glass in a week, or a decade, or a century? Of course not. Pain and suffering matter, whenever they occur.

The second key concept is that there may be a lot of future people. If humanity lasts as long as a typical mammal species, then future generations may well outnumber us 10,000 to 1. This means we are probably at the very beginning of history. It is likely that the vast majority of people – real people, who are capable of joy and suffering just like us – are yet to come.

The third idea is that we can actually do things to improve the lives of future people.

You might be sceptical. It is difficult to predict how our actions will affect our own lives in 10 years, let alone all of humanity in 1000 years. But it would be too pessimistic to throw our hands in the air and say there is nothing we can do to be excellent ancestors. For one, we can fight to reduce the risk of extinction or societal collapse, which could prevent future generations from ever seeing the light of day.

In his book *The Precipice*, my colleague Toby Ord estimates that there is a 1 in 6 chance of human extinction, or another event that permanently destroys humanity's potential, this century. The risk comes from threats like runaway artificial intelligence, pandemics and nuclear weapons. We need to act urgently to reduce these risks by funding safety research in AI, enhancing biosecurity and pandemic preparedness and reducing the likelihood of a war between global powers.

What's more, we can promote values that treat the interests of all people, including future people, with respect and care. Some of the greatest contributions to human welfare in the 20th century were from the feminist and civil rights movements. These expanded the scope of society's moral concern, in order to protect the dignity and interests of women and minority groups. But the rise of totalitarianism in the 20th century shows that values can take a sharp turn for the worse. Without dedicated activism and careful stewardship, there is no guarantee that the arc of history will keep bending towards justice.

There are many ways in which the years to come could go terribly. But a dystopian future is far from inevitable. If we play our cards right, we can give future generations a more flourishing world – one without hunger, poverty, racism, discrimination, mistreatment of animals and so many other evils of the present day.

How might those future generations look back at us? Carl Sagan suggested an answer: "They will marvel at how vulnerable the repository of all our potential once was, how perilous our infancy, how humble our beginnings, how many rivers we had to cross before we found our way."

There is no assurance that we will find our way. But improving the world for future generations is one of humanity's most pressing tasks, and it urgently demands our attention. ▮

MATT CROCKETT

William MacAskill is a philosopher at the University of Oxford and author of *What We Owe the Future*

Health check

A weighty matter The orthodoxy is that anyone with a body mass index of 25 or more is overweight, but evidence suggests the cut-off point should be higher, writes **Clare Wilson**

Clare Wilson is a medical journalist who covers everything life-science related. She writes *New Scientist*'s weekly health newsletter, which goes out on Saturdays, called Health Check

IF, LIKE me, you put on a few pounds during the pandemic lockdowns, you may not be looking forward to your next doctor's visit in case they ask you to step on the weighing scales.

Healthcare staff assess whether people are overweight by calculating their body mass index (BMI), a measure of weight that takes height into account. Those whose BMI is judged too high may be given diet advice sheets or recommended a website, app or slimming clubs.

The link with lockdown is particularly cruel as health bodies also tell us that being overweight puts people in greater danger from covid-19. So anyone concerned about the next coronavirus variant may well feel pressure to follow their doctor's orders.

Most of us would accept that we are being given good advice, whether or not we manage to follow it. But there are reasons to think that such recommendations aren't based on good evidence – and might well be wrong.

It is uncontroversial that people who are very heavy die younger than those who are slim, succumbing earlier in life to conditions such as heart attacks and strokes. They are also more likely to find walking difficult, to get out of breath more easily and to have joint pain.

What is less clear is just where the red line is between being a healthy weight and the danger zone. The standard advice in most high-income countries is that anyone with a BMI of 25 or more is overweight. It is unclear exactly where this figure stems from, but it seems to have been cemented into the medical orthodoxy by a report from a meeting of the World Health Organization in 1997.

Yet there is a good deal of evidence to suggest we should place the cut-off for being overweight a bit higher – perhaps at a BMI of 30 or even more. The question marks over the 25 to 30 bracket are important because it accounts for about half of those who would be medically advised to lose weight in most high-income countries.

The doubts first came from an analysis by researchers at the US Centers for Disease Control and Prevention in 2005 that used a large existing data set from a regular government-run nutrition survey. They found that people whose BMI is between 25 and 30 had a lower death rate over the period of time studied than people whose BMI was in the supposedly ideal range of 18.5 to 25.

> **"What is less clear is just where the red line is between being a healthy weight and the danger zone"**

The findings were highly controversial, but several other pieces of research have investigated the question, and in other countries too. While some disagreed with the 2005 conclusion, the majority concurred, as shown by a 2013 meta-analysis summarising 97 such studies.

This year, a Chinese study confirmed the finding in people over 80 – the age range when most people die. Although the weight categories used don't correspond exactly to those in the UK, this found that even people who would be classed as mildly obese, with a BMI over 28, had a lower death rate than those classed as having a healthy weight, with a BMI between 18.5 and 24.

Even the link between weight and covid-19 danger seems to be overstated, because studies have shown that a raised risk only kicks in at BMIs of 35 and over. Yet most health bodies continue to give the outdated message that if our BMI gets above 25, we weigh too much and should do something about it.

Another key question is how people should go about trying to lose weight, if that is their goal. For decades, doctors have said we should cut out fat from our diet, for instance by using reduced-fat dairy products, avoiding butter and oils in cooking and, increasingly, swerving red meat.

But more recently, randomised trials of different diet approaches have found that aiming for a low-carbohydrate and high-fat diet is as good as a low-fat diet for losing weight and keeping it off, and doesn't cause heart attacks either.

Another alternative is fasting diets, where people intersperse periods of normal eating with bouts of consuming very little. Fasts are usually either for two non-consecutive days of the week or between 8.00pm and midday.

Some believe this works because it regularly flips the body into relying on a different metabolic pathway, others because it simply nudges people into eating less. Either way, it does seem to help some people – and yet it also goes against the usual medical advice not to skip breakfast. It may be that different kinds of dieting suit different people better. But again, this isn't the impression you would get from most medical sources of advice on healthy eating.

So while I hugely respect the staff of my primary care practice, who have provided sterling service to my family during the pandemic, if they ask me to step on any scales, I will politely decline. ▮

Clare's week

What I'm reading

Barbara Kingsolver's Animal, Vegetable, Miracle. *I am fascinated by her attempts to become partly self-sufficient in food*

What I'm watching

Borgen – Power & Glory. *Never would I have thought I could be so interested in Danish political power-sharing coalitions*

What I'm working on

I am taking a deep dive into the age-old question of nature versus nurture for an article

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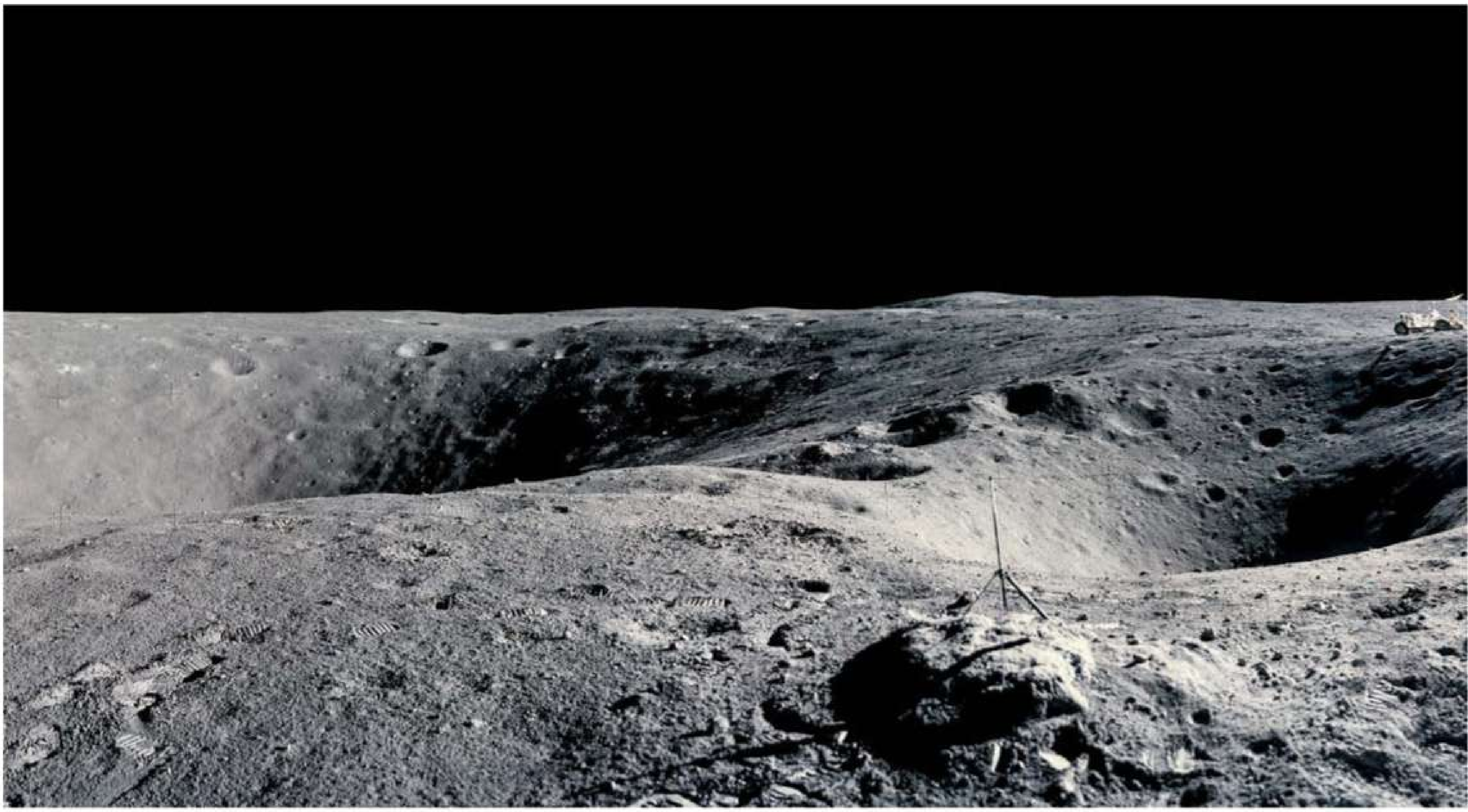
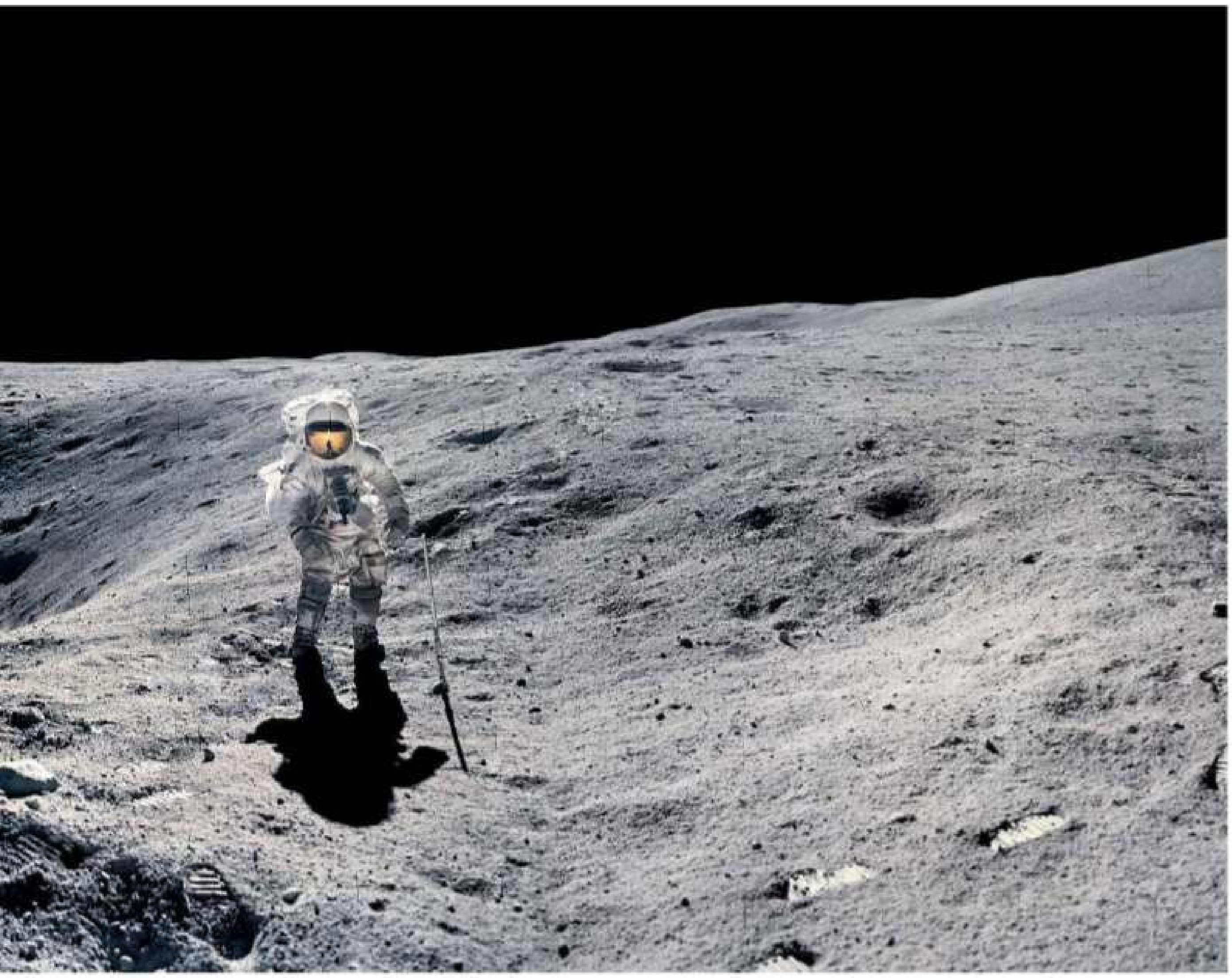
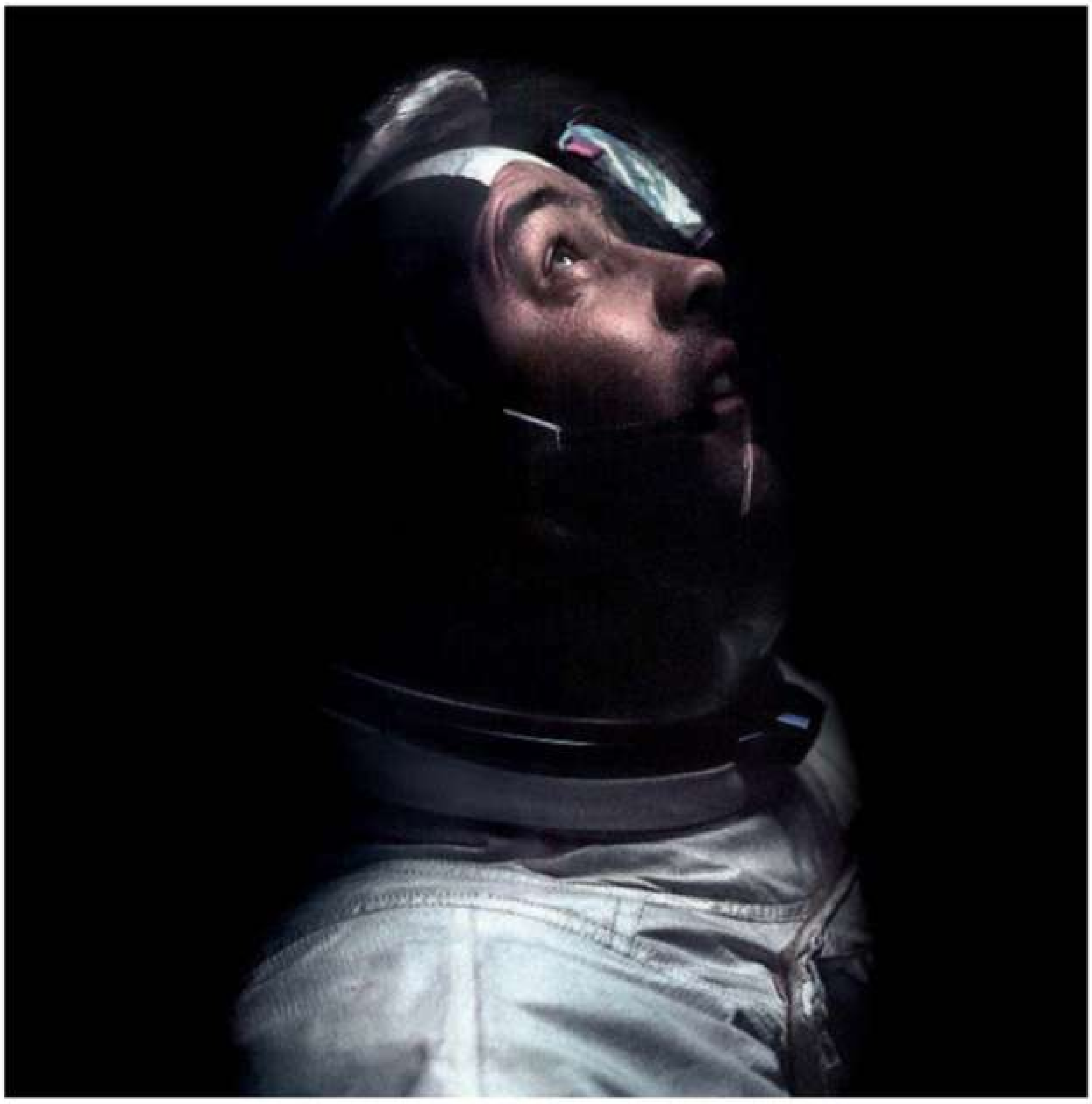


LOWER L + R + TOP: NASA/JSC/ASU/ANDY SAUNDERS

NASA/ANDY SAUNDERS (DIGITAL SOURCE: STEPHEN SLATER)





Moon shots

Publisher **Particular Books**

THESE are the Apollo lunar missions like you have never seen them before. Taken from the new book *Apollo Remastered* by Andy Saunders, these illuminating images have been produced by enhancing original material to reveal new details of NASA's forays in the 1960s and 70s.

Its programme is best known for putting the first humans on the moon in 1969 during the Apollo 11 mission, though it comprised 14 missions in total that covered everything from testing technology to collecting lunar samples. Saunders, who specialises in NASA digital restoration, created the new high-definition images from scans of 35,000 or so originals preserved in a frozen vault in Houston.

The moon's cratered surface is laid bare in the panoramic top picture, taken during the Apollo 16 mission in 1972 and showing astronaut Charlie Duke, the youngest person to walk on the lunar surface at the age of 36.

The bottom row shows (left to right): NASA astronaut Dave Scott during the Apollo 9 mission in 1969, with the Apollo spacecraft and Earth reflected in his visor; cue cards made by Apollo 8 astronaut Bill Sanders to document the upcoming mission of testing the spacecraft in the moon's orbit; and a shot of Apollo 9 commander James McDivitt performing the first docking (or joining) of two crewed spacecraft. Saunders writes that this is the only photo of an Apollo astronaut in their full suit and bubble helmet during flight. The reflections of Earth, and the docking window, can be seen on McDivitt's helmet. ▮

Gege Li

Editor's pick

'Thinking' won't save plants from the axe

Leader, 27 August

From Denis Watkins, St Just in Roseland, Cornwall, UK

You say that extending cognition to plants would mean a seismic shift in our view of humanity's uniqueness. No doubt it would to *New Scientist* readers. But in a world where the Amazon rainforest continues to be felled, would it make any practical difference? We are still far from preventing the extinction of many animals, let alone plants.

From Tim Stevenson, Prestwood, Buckinghamshire, UK

Aha! So the endless contemplation of consciousness has extended to plants! There is an important distinction to be made between consciousness and correlates of consciousness. My consciousness is something I alone experience, and whose explanation I regard as intractable. There are things (correlates) I do that clearly arise from my consciousness. That I observe such things in other people, and indeed some animals and conceivably plants, leads to the plausible conclusion that they, too, are conscious. The step from this to the deduction that they have rights that I should respect is a value judgement that I willingly make rather than one I can prove.

From Brian Horton, West Launceston, Tasmania, Australia

It was once assumed there were many behaviours unique to humans. Now, we have found various animals that can recognise themselves in a mirror, use tools and behave in ways once thought to define us.

You recently reported on a pitcher plant that uses rain to vibrate leaves, causing ants to fall into the pitcher (13 August, p 22). I expect we will soon have evidence that climbing plants can make use of a mirror to locate themselves and find poles to climb.

Where to find solutions to the water shortage

20 August, p 9

From Louise Condon, Bristol, UK

Your look at water shortages in England reports that consumers have a responsibility to restrict use, but skates lightly over the water industry's responsibilities.

Despite very large profits since privatisation, these companies have failed to invest adequately in infrastructure to conserve water. In addition to leaking pipes, no new reservoir has been built in England since 1991, meaning that more water is pumped from groundwater sources, which stresses the environment.

From Mike Clarke, Castle Hedingham, Essex, UK

Regarding ways to address water shortages, it is pointless to avoid building surface water reservoirs on the basis that this reduces available farmland, as one reader argued (Letters, 27 August). If there is no water, there can't be fertile land. Like energy supply, there is no single, simple solution to fresh water storage and supply. Every option has downsides.

Good luck to interstellar meteorite hunters

20 August, p 16

From Bruce Denness (former professor of ocean engineering), Niton, Isle of Wight, UK

I hope Avi Loeb and Amir Siraj at Harvard University are successful in raising funds to search for fragments of the iron-rich, potentially interstellar object that landed in the Bismarck Sea north of Papua New Guinea in 2014. Should they do so, I think their chances of finding their quarry are quite good as the depth in most of that sea is less than 2000 metres or so, and even at its fastest, the westbound South Equatorial current shouldn't have taken the sinking fragments far from the 10-by-10-kilometre target area.

If the mission were successful, the scientific reward could be huge. It would lead to the first analysis of an object (including its age) from a source other than in, or fairly near, Earth's own orbit. In turn, that could have implications for how the solar system evolved, as well as the object's own origin – a cheap endeavour at $1.6 million.

Resolving the universe's most mysterious numbers

13 August, p 42

From Ton Smit, Utrecht, The Netherlands

The doppelgängion number suggests an exact copy of me could exist in the universe. I don't believe this is possible.

For someone to be exactly the same as me in this moment, that person wouldn't just need to have the same arrangement of fundamental particles as me, which is what the number quantifies, but also to have had the same life experience: the same parents, friends, teachers and so on. For that to happen, those friends etc. also need to have had the same life experiences as those in my world have had.

From Raymond Cannon, Blackwater, Hampshire, UK

You raise the issue of where all the antimatter has gone, assuming it was produced in equal amounts to matter when the universe began. It has been said that antimatter can't be distinguished from matter moving backwards within time.

I suggest that all the matter observable to us is "moving" away from the big bang "forwards" in space-time. All the antimatter is "moving away" from the big bang "backwards" in space-time and so is forever hidden from us.

How much risk should astronauts accept?

20 August, p 14

From Bryn Glover, Kirkby Malzeard, North Yorkshire, UK

You report that the European and Russian space agencies think that a 1 sievert dose of radiation is acceptable for astronauts. Given many estimates predict an average 5 per cent rise in cancer fatality risk per sievert, this sounds like an enormous level of risk.

Actually, the pie aisle may be greener than it sounds

13 August, p 13

From Guy Cox, Sydney, Australia

That buying baked foods such as pies has a larger carbon footprint than buying raw vegetables is hardly surprising, since energy is always needed to prepare and cook them. The real question is, does buying a pie have a larger or smaller carbon footprint than buying the ingredients and baking your own? My money would be on the supermarket pie because of economies of scale. But I know which would be tastier!

Surely we can get our fizz from captured carbon

20 August, p 13

From William Croydon, Sandown, Isle of Wight, UK

With ongoing research on carbon capture and storage, I am amazed that the US permits extraction of ancient, buried carbon dioxide for use in "bubbly beverages" and food processing. We must get back to a system in which by-products are used for something, rather than treated as waste to be dealt with by someone else, all the while buying in an equivalent product with all the associated environmental impacts. ▮

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The way of the shark

Two powerful books aim to help turn the all-too-common public panic about the predator into interest in their conservation, finds **Elle Hunt**

Books
Shark
Paul de Gelder
HarperCollins

Why Sharks Matter
David Shiffman
Johns Hopkins University Press

BY FEBRUARY 2009, Paul de Gelder had spent thousands of hours in the water as part of his job as a diver in the Australian Navy.

Early one morning, he was conducting a counterterrorism trial, swimming solo around Sydney Harbour, when he was attacked by a 3-metre-long shark. The fish slammed into him with its jaws, pinning de Gelder's right hand to his leg. He recalls being shaken like a rag doll, feeling more pain than he had ever imagined possible. Then the shark let go.

"Several surgical operations later," writes de Gelder in his new book, *Shark*, "I woke up to find that I was missing half an arm and a leg." What comes next in this amazing story is unexpected. As soon as he was able to, he returned to the water – and, seeking to understand exactly what had happened to him, he started reading about sharks.

The attack may have ended de Gelder's military career, but it led to a new one: as a presenter for Shark Week programmes on the Discovery Channel and as a passionate advocate for shark conservation.

In *Shark*, he sets out to justify its subtitle, "Why we need to save the world's most misunderstood predator". It is an accessible book, methodically skewering common myths and misrepresentations before showing how overfishing and other human activities are driving sharks to extinction.

SHUTTERSTOCK/LEONARDO GONZALEZ

A bull shark (*Carcharhinus leucas*) swimming in the Pacific Ocean

Those who already share de Gelder's fascination with sharks, or who seek the science about them, may not learn much. He becomes a guide for those who need help overcoming their fear with his infectious interest and military straight-talking, though he is notably circumspect on what Shark Week and his role in programmes such as *Bride of Jaws* have done to stoke unsubstantiated fears.

Even so, de Gelder's uncommon perspective does distinguish the book, and it amplifies his call to protect sharks: if he sounds the alarm, the rest of us should at least take notice.

Another new book mounts a more pointed argument. *Why Sharks Matter: A deep dive with the world's most misunderstood predator* is the first book by marine conservation biologist David Shiffman at Arizona State University in Tempe, who has gained a large Twitter following thanks to his educational and entertaining posts.

Shiffman retains that chatty style in print, but takes the reader on the kind of "deep dive" precluded by Twitter's character limit. The book is littered with bits of trivia and detail about sharks that could only be amassed through detailed research.

But Shiffman's focus is less on mounting a persuasive, general case for a much-maligned predator than on highlighting effective, smart solutions for conserving them.

He has an outspoken, even combative style when it comes to misdirected or ill-informed advocacy, such as that of online petitions – a particular bugbear of his. Thankfully, Shiffman is just as quick to celebrate those who advance the interests of sharks, profiling a diverse group of dedicated scientists (itself laudable in a field dominated by white men). His bluntness and specificity is refreshing in the face of so much advocacy that just sets its sights at "raising awareness".

In the decades since the book and the film *Jaws*, there has been a concerted effort to rebrand sharks from mindless killing machines to infinitely interesting marvels of evolution and essentials of ocean ecosystems. Even Shark Week now attempts some balancing of fearmongering and fascination.

Where de Gelder and Shiffman align is in their condemnation of irresponsible coverage of sharks, their calls for the public to be both curious about sharks and active in saving them, and in their undeniable knowledge and passion. But neither quite succeeds in telling a shark story as straightforwardly compelling as Peter Benchley's *Jaws* (as Benchley himself realised, dedicating the rest of his life to conservation).

Today, most people with a passing interest in the natural world recognise that even the most fearsome predators are more endangered by us than are a danger to us. Ironically, that fear factor – if responsibly and strategically deployed – could prove their secret weapon against the biggest threat of all: human apathy. ▮

Elle Hunt is a writer based in London

Back to the Internet

The internet's early days were quieter, more intimate – and spelled with a capital "I". Should we go back, asks **Jacob Aron**

Book

Escape

Marie Le Conte

Blink Publishing

I CAN'T remember the exact moment I first used the internet, but as it would have been the late 90s, I would have called it the Internet with a capital "I". I surfed the information superhighway, merrily mixing metaphors as I explored this strange realm. I even had a printed book suggesting cool websites to check out, like The Really Big Button That Doesn't Do Anything.

I am slightly older than Marie Le Conte, who has written a book that is part personal memoir, part eulogy to the web that was, but we share the experience of growing up online. Reading *Escape: How a generation shaped, destroyed and survived the internet*, I was surprised by just how similar our online teenage lives were.

Like Le Conte, I would come home from school, log on to the chat program MSN Messenger and spend the evening talking to friends I had just spent the whole day with. We also both had blogs, in which we freely shared details of our teenage lives without thinking about who was going to read them.

Essentially, the internet Le Conte and I occupied was small. Yes, you could theoretically connect to millions of people, but people tended to organise themselves into small communities around blogs, forums and other online hangouts. In fact my blog, a group blog, acted as a community for school friends and random people I met online.

"Le Conte and I both had blogs, in which we freely shared details of our teenage lives without thinking"

Le Conte's thesis is that, with the rise of social media platforms like Facebook and Twitter, and the fact that many more people now use the internet, something special has been lost. "We found a home then it was invaded; it was no one's fault, not really, but now everyone is here and our home is gone," she writes.

I think you really have to be from the same generation as Le Conte and me to appreciate this shift, and perhaps to get the most out of *Escape*. While it sits nicely on the shelf with *Because Internet* by Gretchen McCulloch, a fantastic exploration of how the online world has transformed language, that book is very much about the internet now, rather than *Escape*'s examination of the internet that was. And despite Le Conte's best efforts, there is something about the early internet that means, like its 1990s contemporary *The Matrix*, you can't be told what it is – you had to see it for yourself.

Le Conte also explores some of the issues arising from everyone now being online. There is a famous cartoon, published in *The New Yorker* in 1993, captioned "On the Internet, nobody knows you're a dog". It was true: online you could be anyone you wanted to be, adopting different personas as you flitted between communities.

Today, it is possible for your tweets to be read by your best friend from school, your parents and your boss – not to mention angry people you have never met. It is no surprise that things get taken out of context, a phenomenon known as context collapse. Le Conte calls this the Opera Singer Conundrum, after she tweeted a complaint about her opera singer neighbour who practised loudly – and got barraged by messages from other opera singers defending her neighbour.

Is it possible to reclaim the older, friendlier internet? Le Conte thinks so. In 2020, she created a private Twitter account to allow her to address a much smaller group. It is a trend that Twitter itself seems to be embracing – it has just launched a function that lets you restrict tweets to a select circle of 150 followers.

Perhaps we could all do with taking a page out of Le Conte's book, and retreat into the quieter corners of the internet once more. ▮

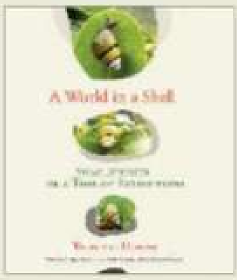
The internet's early days: an IBM Web Server 400 at the Internet Fair in Berlin on 29 May 1997

DPA PICTURE ALLIANCE/ALAMY

Don't miss

Watch

The Handmaid's Tale begins a fifth, possibly final, season with June (Elisabeth Moss, pictured) working against Gilead's repressive theocracy. On Hulu in the US from 14 September, but UK viewers must wait.



Read

A World in a Shell is "real-world" philosopher Thom van Dooren's cultural and ecological analysis of Hawaii's land snails. The islands once had more than 750 species, almost two-thirds of which are now extinct. On sale 13 September.

Visit

British Science Festival is Europe's longest-standing science festival, taking place this year in Leicester, UK. Enjoy science rapper Jon Chase, real-life dragons, creative AI and more. Runs from 13 to 17 September.

TOP: HULU; BOTTOM: STEVE BRADING

The TV column

Dark side of the moon From a parched Earth, Song Ji-an joins a lunar mission to find out how her sister died. It gets bad, very bad. With nods to the 1972 *Solaris* and *Alien*, word-of-mouth hit *The Silent Sea* is an intriguing show, says **Bethan Ackerley**

Bethan Ackerley is a subeditor at *New Scientist*. Follow her on Twitter @inkerley

NETFLIX

Song Ji-an (Bae Doona) joins a mission that finds a terrifying truth

TV

The Silent Sea

Director Choi Hang-yong

Netflix

IF YOU live in Europe, this seems an appropriate time to watch *The Silent Sea*. With even rainy nations touched by what may be the continent's worst drought in 500 years, it is easier than ever to imagine an arid future for Earth.

This South Korean sci-fi thriller debuted on Netflix in December last year to little fanfare, but its acolytes have spread the word and it is now a word-of-mouth hit.

It is set at a time when most of Earth's oceans have dried up, water is strictly rationed along class lines and pets are euthanised as an unnecessary drain on resources.

This desiccated Earth haunts Song Ji-an (played by Bae Doona), a former astrobiologist who is grieving for her sister. Five years earlier, she was one of 117 people who died at Balhae Station, a South Korean research unit on the moon.

In a bid to learn what happened to her, Ji-an joins an elite team on a mission to retrieve a mysterious sample from the abandoned facility. What they discover is terrifying beyond comprehension.

First, a disclaimer: if you are a stickler for accuracy, *The Silent Sea* isn't for you. The physics bears almost no resemblance to the actual conditions of our moon. This isn't *For All Mankind*, a show where the perils of space exploration are rendered with queasy realism – this is horror.

That said, after a slow set-up, *The Silent Sea* gradually weaves together elements of sci-fi and mystery to create something truly intriguing. Arriving at the station, Ji-an and the crew quickly realise that the dangerous radiation levels they were warned about, supposedly a consequence of the incident five years ago, aren't present. The facility is full of the bodies of people whose deaths make no sense, and the sample they are seeking turns out to be far more dangerous than they had anticipated. What's more, they realise they aren't alone.

> **"Existing on the fringes of the known, Ji-an and the crew face something that bends their rules of reality"**

Fans of *Alien* and the 1972 *Solaris* will recognise the DNA in the twin threats faced by Ji-an and her colleagues. The series exploits the fact that space is a perfect setting for horror – after all, exploring our solar system has forced us to redefine our notions of what is possible and what is ethical. At the intersection of these uncharted waters lies the potential for great suffering. Here be dragons.

Removed from Earth, existing on the fringes of the known, Ji-an and the crew face something that bends their rules of reality. And as the team members are picked off one by one, internecine struggles between the survivors threaten the mission's success.

A few of *The Silent Sea*'s twists are over-telegraphed and under-explored, such as the exact nature of the involvement of a shadowy, resource-stealing corporation. But these are minor cavils compared with the show's assets, from its bleak, uncanny tone to its highly talented cast, which includes *Squid Game* scene-stealer Gong Yoo as mission leader Han Yoon-jae.

From the wise-cracking doctor Hong Ga-young to the sinister co-pilot Lee Gi-su, each one of what looked like a band of stock characters is beautifully realised by the end of the eight-part series.

At its peak, *The Silent Sea* is far more engaging than many of Netflix's sci-fi offerings. While its fate is in limbo, with no word on a second season, the series works as a self-contained, bingeable story.

And for those living in nations that have been struck by drought, the show is a timely reminder that our treatment of Earth could drive us to far darker places in search of restitution. ▮

Bethan also recommends...

TV

For All Mankind

Created by Ronald D. Moore, Matt Wolpert, Ben Nedivi

Apple TV+

This alternate history of the space race shines when it explores the real dangers of space exploration. Warning: the tiniest tech malfunctions lead to terrifying scenes.

The Expanse

James S. A. Corey (multiple authors)

Amazon Prime Video

Not only breathtakingly entertaining, the show also provides pure nightmare fuel via the mysterious and deadly protomolecule. Watch at your own risk.

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*Source: Google Analysis Jan-Dec 2021

Instant power

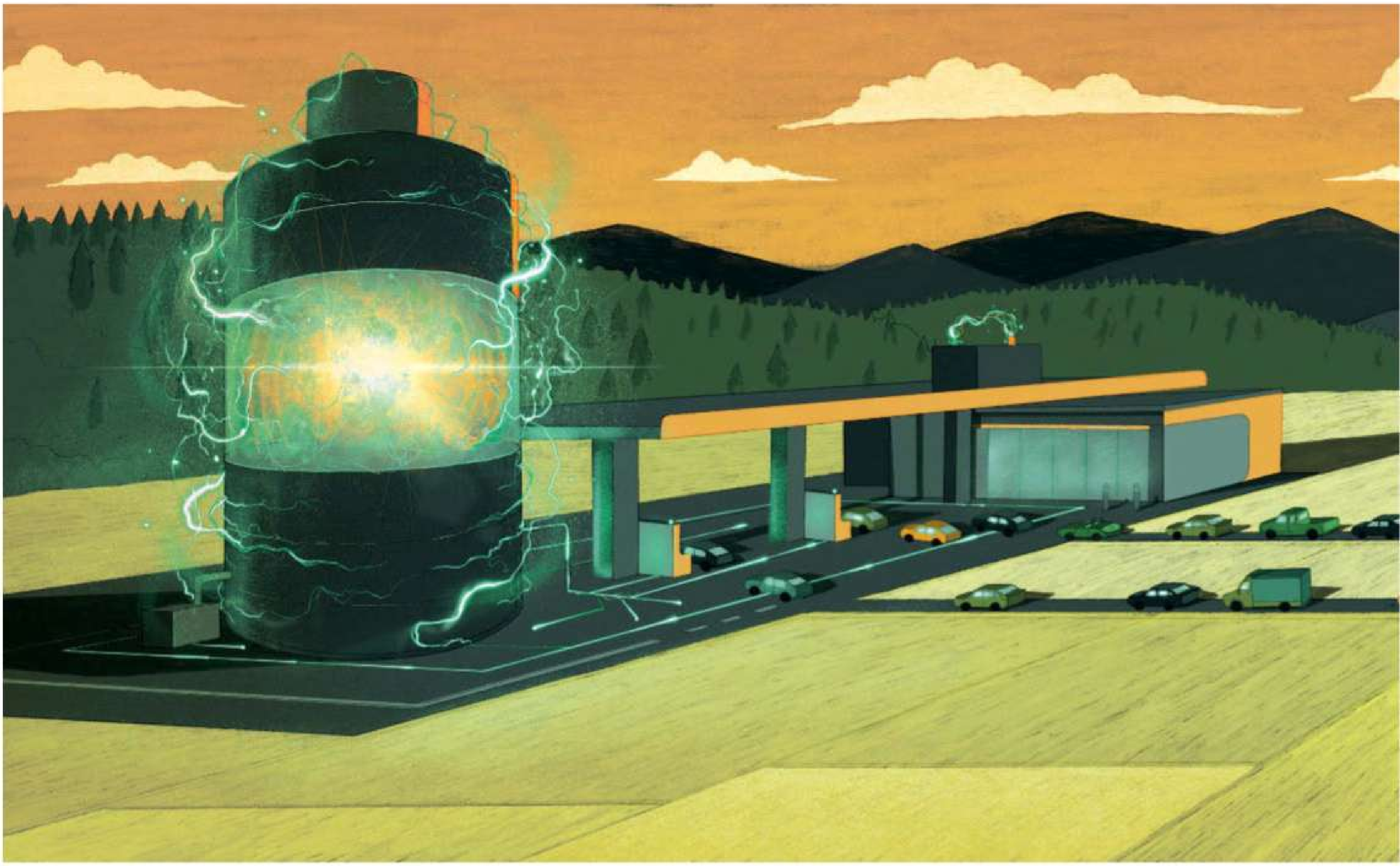
Quantum batteries that recharge in a flash could accelerate the electric car revolution, says **Jon Cartwright**

THE battery, as US comedian Demetri Martin pointed out, is one technology that we personify. "Other things stop working or they break," he said. "But batteries – they die." The observation is keener than it may at first appear. So beholden are some of us to smartphones, tablets and other digital technology, that our lives pretty much go on hold when they run out of juice. Even if it is just 30 minutes, we are apt to mourn the time lost to recharging.

If that seems like a laughable reaction, there is a serious side to this when it comes to the batteries that power electric vehicles. The fact that it usually takes hours to charge them is a major stumbling block to decarbonising transport, which is among the biggest global emitters of greenhouse gases. For humanity's sake, charging times need to be slashed. Yet, with the fundamentals of battery science the same as they were half a century ago, the prospect of a drastic improvement looks slim.

Slim, but not impossible. Now, quantum physics could ride to our rescue. By leveraging the strange behaviour of subatomic particles, a quantum battery could charge itself much faster than any conventional device. As a handy bonus, the bigger a quantum battery, the better it performs. Although the concept is in its infancy, a recent experimental demonstration and some theoretical advances suggest that a world of uninterrupted portable power isn't so far-fetched. One day, dead batteries could spring back to life in an instant.

Technically speaking, a battery is anything that can store energy, from the wind-up spring inside a child's toy to the lake created by a dam that stems the flow of a river. For most of us, though, the word is associated



SIMONE ROTELLA

with electrochemical batteries, either the single-use ones in your TV remote or the rechargeable ones in smart devices and electric cars, bikes and scooters. In fully charged electrochemical batteries, electrons and ions are forcibly separated from the electrodes they are attracted to, storing energy. Turn on the device the battery is in – that is, connect the battery's electrodes – and suddenly these charged particles are able to flow, releasing their pent-up energy as electricity.

The current supremacy of the lithium-ion rechargeable battery, which won its developers, John B. Goodenough, M. Stanley Whittingham and Akira Yoshino, the Nobel prize for chemistry in 2019, is down to its relatively high capacity and longevity. It has also proved faster to charge than the competition, but only by so much. Charge a lithium-ion cell too quickly and the lithium ions stick irreversibly to the positive electrode, rendering the battery useless, even potentially explosive, over time. As a result, electric cars that use today's lithium-ion technology will probably always take significantly longer to charge than the time to refill a petrol or diesel vehicle.

Practical issues such as these weren't uppermost when Robert Alicki at the University of Gdańsk in Poland and Mark Fannes at KU Leuven in Belgium first formally proposed the concept of the quantum battery a little under a decade ago. As theoretical physicists, they were interested in whether the basic concept of such a battery could shed any light on a bigger question that has troubled physicists for several generations: why is the behaviour of small numbers of isolated particles so different to the behaviour of visible everyday objects, which are, after all, just sizeable collections of those very same particles? As physicists see it, there is a puzzling transition between the "quantum" world of the very small and the "classical" world of the reasonably big.

The quantum world is slippery by nature. Out of sight – or, to put it properly, unobserved by any means – a single particle ceases to have definite properties. Rather, it is in a superposition, simultaneously both here and there, in this state or that state. It can also act in concert with other isolated particles, the state of one instantly influencing the states of the others, even over vast distances, a phenomenon known as entanglement.

Quantum quirks

Scientists who develop batteries don't usually concern themselves with such mysterious goings-on. The charge of a conventional battery involves the displacement of 10 billion billion electrons or more, a long way from the usual quantum physics description of a small number of particles. For battery scientists, a classical theory that deals with tangible, large-scale properties such as heat, energy and physical work will do fine. That theory, historically, has been thermodynamics.

Thermodynamics is unmatched in its ability to describe the workings of engines, heat pumps, boilers, batteries and other familiar sources of power. It has even been usefully applied to much more exotic objects, from black holes to the universe itself. The key to ›

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its success has been its insensitivity to what individual particles get up to. Most practical systems consist of large numbers of component particles, so it has been sufficient, in the scheme of thermodynamics, to deal with averages. In recent years, however, theorists have begun to pick at this assumption. Are thermodynamic laws still valid if they are applied to individual particles, with their quantum quirks? And might the answer to this shed light on the transition between the quantum and classical worlds? What better way to try to get at the answers than a device defined only by its ability to store energy temporarily, however big or small. The battery was, for Alicki and Fannes, a potential testing ground for such questions. The pair set out to devise a battery based on quantum rules.

Qubits in tandem

Superficially, a quantum battery isn't much different from an ordinary one. It consists of "stuff" that prefers to exist in a low-energy state, like water at the bottom of a dam, but which can be forcibly put in a high-energy state until it needs to power something. In a quantum battery, this stuff comprises quantum bits or "qubits". This refers to anything that can exist in a superposition of different states at once, such as electrons, ions, molecules or pulses of light. Theoretically, it doesn't matter what the qubits are made of, though practically they must be amenable to precise manipulation in order to generate quantum entanglement – in this case, an inextricable link between at least two qubits. In 2013, Alicki and Fannes calculated that, as more and more qubits in a quantum battery are entangled, the amount of energy that can be extracted from that battery approaches a thermodynamic limit. In other words, they found that entanglement makes a battery's capacity as big as it can be in the classical view.

This lack of advantage over conventional batteries could be seen as an anticlimax. Despite the seemingly unreal nature of quantum physics, the capacity of a battery devised on its principles is still subject to the same limit as that of any other battery. "Thermodynamics is neither quantum nor classical," says Alicki. "It provides a kind of ultimate censorship for physical theories." Indeed, quantum physics may not even provide the leg-up to the ultimate thermodynamic limit that Alicki and Fannes thought possible. Later in 2013, Karen Hovhannisyan at the ICFO-Institute of Photonic Sciences in Barcelona, Spain, and others showed that the same amount of energy can still be extracted from a quantum battery without entanglement, so long as many attempts at extraction can be made.

Still, Alicki and Fannes's work did fuel a suspicion that, whatever the thermodynamic constraints, a quantum battery could hold an advantage over a classical one. In 2015, theorists including Kavan Modi at Monash University in Victoria, Australia, realised that, while it might not improve the total extractable energy of a battery, quantum entanglement could improve something of perhaps greater practical utility: how fast a battery can be charged.

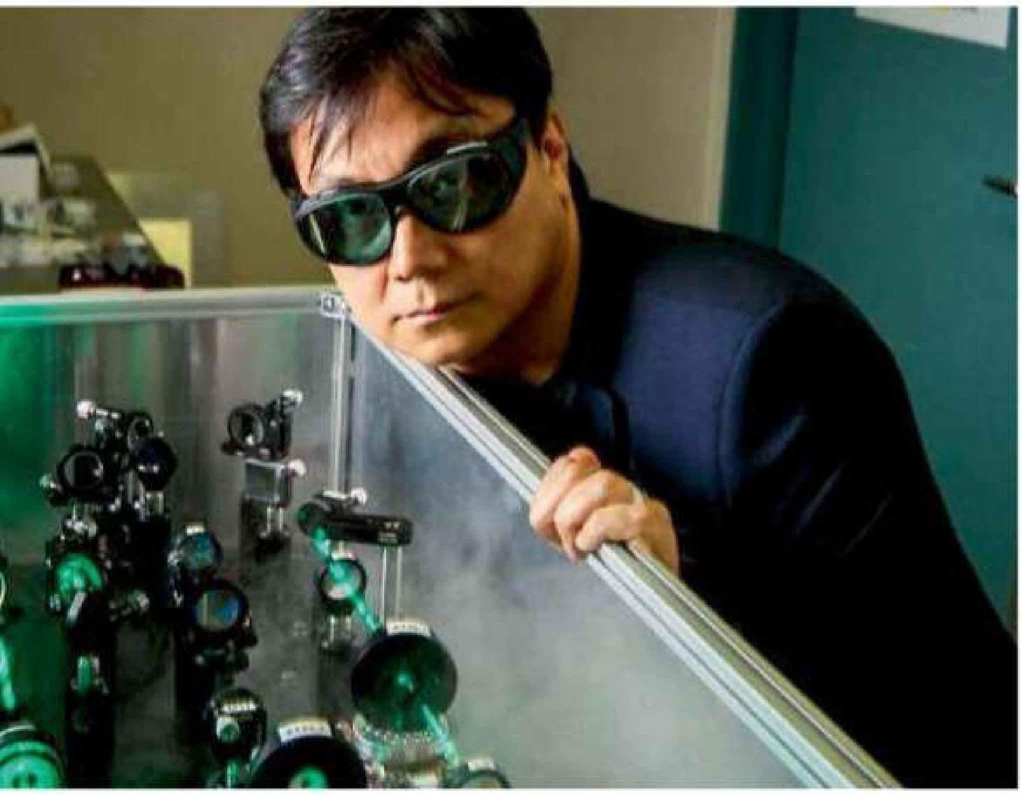
Why this is so takes us deep into the mysteries of quantum behaviour. When a classical battery charges, it effectively has to go on a journey from a low-energy state to a high-energy state. Think of it like a cyclist pedalling along a straight path from A to B. The bigger the energy gap, the longer the journey and the longer the charging time. In a quantum battery with only a single qubit, the same would be true. But entangle a second qubit with the first and a shortcut emerges. The original journey from A to B is a straight line only when seen from above; seen now from the side, myriad hills and valleys that were secretly slowing the cyclist's journey become apparent. Working in tandem, the two qubits are able to ride a flatter, faster route to the high-energy, or charged, state.

It doesn't end there. Entangle a third qubit and another unforeseen dimension to reality suddenly manifests, one that betrays a still-faster route to a full charge. A fourth, a fifth, a sixth qubit: with every addition, the indirectness of the original route is peeled away, and a faster line becomes possible. In fact, according to Modi and his colleagues,

> **"Quantum computers are already quite well designed to be quantum batteries"**

Quantum batteries could cut charging times for electric cars

JUSTIN KASE ZSIXZ/ALAMY



AAP

James Quach shone lasers through molecules of an organic dye to demonstrate a simplified quantum battery

the charging time of a quantum battery is inversely proportional to the number of entangled qubits. The bigger the battery, the faster it charges.

No one knows how best to interpret this higher-dimensional character of the quantum realm – whether the extra dimensions have a physical reality or whether they represent the surface of a deeper reality we have yet to fully uncover. What physicists do know about calculations involving them is that, to put it simply, they work. Super-powerful quantum computers, super-secure quantum communications, super-sensitive quantum detectors – all these technologies involve similarly intangible higher-dimensional mathematics, and have been proven experimentally.

In January, James Quach at the University of Adelaide in Australia and others demonstrated the advantage of the quantum battery in practice, too. Based on a blueprint created by physicists at the Italian Institute of Technology in Genoa, their simplified quantum battery consisted of molecules of an organic dye – not qubits proper, as they couldn't be fully entangled, but all identical and having a low-energy and a high-energy state. The experimenters put the molecules in a cavity between two small mirrors and shone a laser on them. The result was a speed of light absorption, in effect a charging of the overall battery, that far exceeded what would have been possible if every molecule were absorbing by itself, without entanglement of any sort.

The full impressiveness of this experiment depends on your point of view. There were about 10 billion molecules, a lot for a quantum system, but holding an electronic charge equivalent to just one-billionth that of an AA battery. Because the quantum charging advantage depends on the system's isolation from its surroundings, theorists, including Alicki and Modi, are doubtful that it will prove possible to scale up for practical use. "For us, the theory was just an interesting playground to explore fundamental ideas of time and energy," says Modi. "I don't think there will be technological applications. Of course, I may be completely wrong."

Drive-through charging

Others are more optimistic, stressing that problems of isolation affect all quantum technologies, not just batteries. In April, Ju-Yeon Gyhm, Dominik Šafránek and Dario Rosa at the Institute for Basic Science in South Korea carried out further theoretical work looking at the maximum possible charging speed-up for quantum batteries. They point out that, while relatively small in total, the energy stored in the experiment by Quach and his colleagues had a density roughly equivalent to that of a common lead-acid car battery. In principle, they say, future quantum batteries could charge so swiftly that the operation is practically unnoticeable. For electric cars, it is possible to imagine a drive-through charging station, one in which you don't even need to stop. Such a future may be some way off, however. "Maybe I won't live long enough to see it," says Rosa, who is in his late 30s.

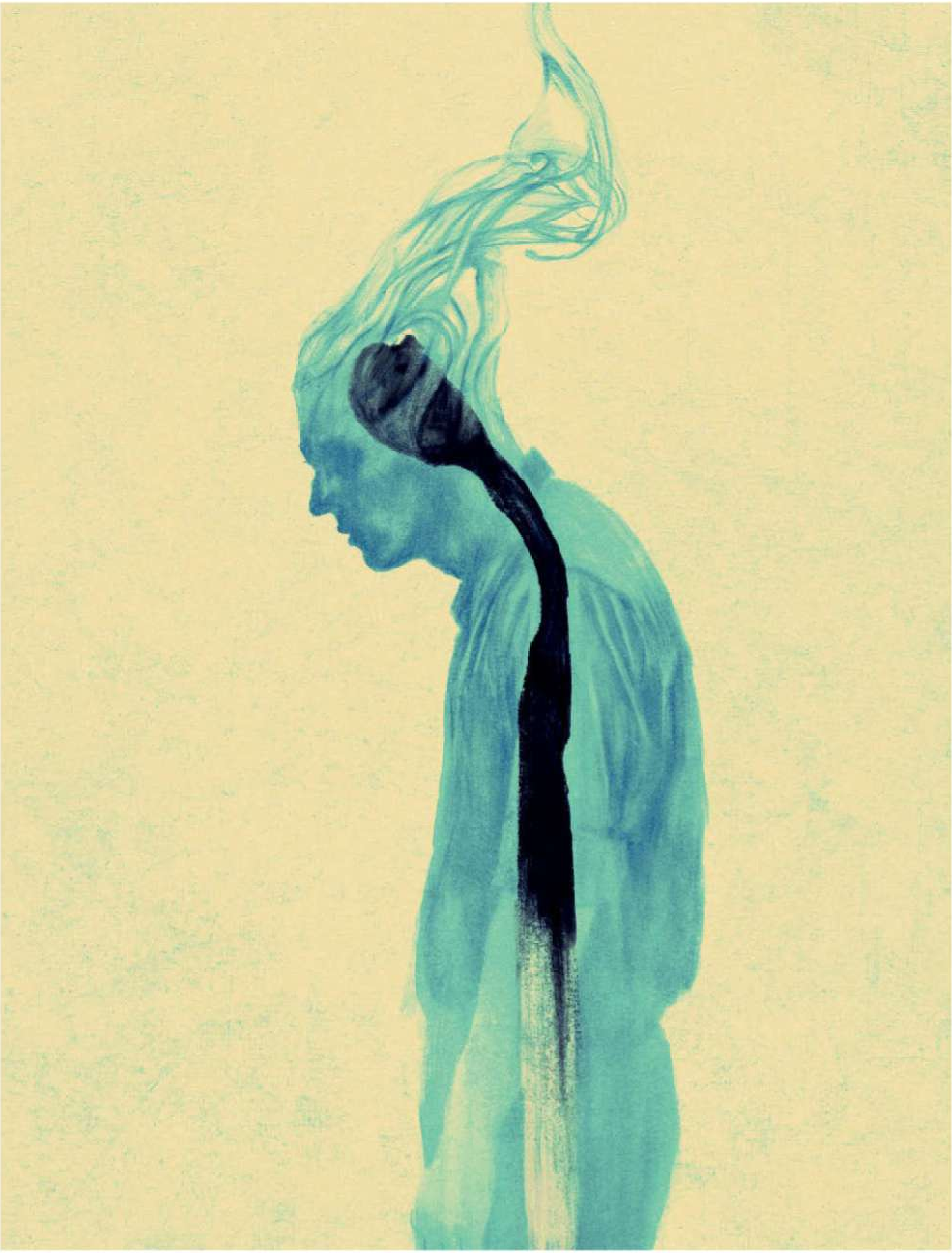
Help could actually be hiding in plain sight. Dario Ferraro, a theorist at the University of Genoa in Italy, believes progress can be made by capitalising on work on existing quantum computers, which are also built from qubits and which, more importantly, have huge investment behind them. In April, he and his colleagues in Genoa and at the CERN particle physics laboratory near Geneva, Switzerland, showed that an IBM quantum computer might actually perform better as a battery. This is because errors that affect its quantum computation, and which are hard to reduce as such machines scale up, have little effect on energy storage. "Quantum computers are already quite well designed to be quantum batteries," says Ferraro, possibly even as self-powering devices.

Quach sees advances in unexpected areas as well. For example, the quantum boost behind the accelerated light absorption in his group's experiment could also be exploited to improve the efficiency of solar cells, he says. But he isn't losing sight of the quantum battery as a potentially revolutionary concept in itself. Although the isolation required for quantum effects poses issues for scaling, he points out that a certain amount of contact with the classical environment, technically known as decoherence, is actually good for charge storage, as it prevents quantum effects from rapidly discharging the battery again. "It needs some tuning," he says. "Too much and it stops the charging behaviour." For the quantum battery, purely from a practical point of view, controlling the tension between the quantum and classical worlds looks important.

On that practical note, Quach and his colleagues have work to do. Their molecular cavity stored only photons of light. To convert that light to electricity that is usable in classical, modern technology, they must somehow incorporate a conductive layer that electrons in the charged molecules can hop into. They need to rope in more molecules, too, perhaps billions more. After all that, he says, they might have a quantum battery powerful enough to illuminate a tiny light-emitting diode, like the one that shows your TV is on standby.

No immediate solution to the climate crisis, then. But coming from the quantum world, the dazzling workings of which are almost always hidden from view, that little light would be an exciting glimmer of progress. ▮

Jon Cartwright is a freelance journalist based in Bristol, UK



PETER STRAIN

Figuring out fatigue

The past few years have been exhausting, not least for those with long covid. The good news is that we are finally beginning to understand why fatigue strikes and how to tackle it, says **Dana G. Smith**

IF IT feels like you have been running on empty recently, you aren't alone. Amid the turmoil of the past few years, a bone-weary sense of tiredness has become a familiar part of life for many.

Fatigue might be the most universal experience of the pandemic. It is one of the primary symptoms of both covid-19 and long covid, as well as the burnout and depression that have accompanied the stress of the past two-and-a-half years. Even Zoom fatigue, exhaustion brought on by video meetings, has become a recognised phenomenon.

One silver lining of all this is that it has brought fatigue, both in its everyday and more persistent forms, to the forefront of the scientific agenda. For decades, fatigue was dismissed as a fuzzy symptom with no clear biological origin. Now, research is revealing that it is the result of an ongoing conversation between the body and the brain about how much cellular energy is available. A better understanding of the many pathways involved is bringing hope for tackling it. With chronic fatigue affecting nearly 1 per cent of the global population (a number that could now be an underestimate due to long covid), and 25 per cent of healthy people reporting regular struggles with fatigue, finding new avenues for relief has never been more important.

There are many different drains on our energy that can act as triggers of fatigue. Exhaustion can follow a bout of flu, a hard workout, a long day at the office or it can be due to a post viral syndrome such as long covid. While these causes of fatigue are very different, how they manifest in the brain is remarkably similar. The thing that varies is what saps the body's energy and whether there are any barriers that stop it from being restored.

"The analogy I always give is if there's a forest fire in front of you, it could have been [caused by] a careless smoker, it could have been a lightning strike or it could have been a firework. But the end result is this forest fire," says Michael VanElzakker, a neuroscientist at Tufts University in Massachusetts.

In the brain, there are four key areas that keep track of available cellular energy and work together to predict whether the outcome of performing a task will be worth the investment needed to act.

Two of these regions, the insula and the anterior cingulate cortex, are part of the brain's interoception network, which is in charge of monitoring the body's internal state. Their job is to keep track of energy levels and how hard the body and brain are working, and to flag if there is a mismatch. The other two brain regions are the prefrontal cortex, which is important for self-control and future planning, and the striatum, part of the brain's reward network, which signals the potential pay-off.

These four regions perform a cost-benefit analysis to determine how much energy is available and whether an action is, biologically speaking, worth the effort. When cellular energy levels are low, the benefit must be higher to outweigh the energy cost. If the sums don't add up, fatigue sets in.

This analysis is carried out by the fatigue network, the output of which is motivation. While motivation is a loaded term, in a scientific context it isn't about desire or willpower, it is about managing resources. "The fact that you're not willing to expend effort for a reward doesn't mean that you're lazy," says Andrew Miller, a psychiatrist at Emory University in Atlanta, Georgia. "It means that your body is doing a certain calculus, and that calculus is that I don't have the energy reserves to expend in order to go and do that activity."

Scientists have seen this relationship ›

For more on the brain-body connection, hear Moheb Costandi speak at New Scientist Live
newscientistlive.com

between motivation and fatigue in healthy volunteers performing tedious memory and attention tasks. After concentrating for long periods, performance starts to decline and they report feelings of fatigue. In the brain, this shows up as a decrease in activity and connectivity in that fatigue network. However, if at the end of the experiment people are offered a monetary bonus based on their scores, they become reincentivised to put in more effort, and they subsequently perform better and show increased brain activity again. With money on the line, the brain deems the reward to be worth the effort again.

Rest and recharge

Even with incentives, though, after an extended period of concentration, our cellular energy stores become depleted, metabolic by-products begin to build up and performance starts to decline. The same is true for physical effort: people show an initial burst of brain activity in parts of the fatigue network during a test of strength, but there is a decline in activity in the circuit as muscle strength runs out.

Usually, this is temporary. After resting, sleeping or eating, energy stores are replenished and you no longer feel fatigued. With chronic forms of fatigue, though, this doesn't happen (see "When sleep doesn't work", right). Research is beginning to reveal why, by focusing on problems in the production of energy in the cells, or the way the body delivers energy to where it is needed.

When you perform a challenging task, either mental or physical, your brain or muscles require more energy to work harder. Part of that extra energy comes from increased blood flow, which carries more oxygen to the active area, and part comes from tapping into the body's glucose reserves.

There is evidence that in some cases of myalgic encephalomyelitis/chronic fatigue syndrome (ME/CFS), for reasons that aren't known, the body switches from using glucose to a less efficient fuel source, such as fats or amino acids. Other studies have shown that the cells in people with ME/CFS are unable to produce enough energy, both before and during a period of stress, which may explain why fatigue gets worse after physical or mental exertion. It is possible that this happens because cells are unable to get sufficient oxygen and glucose from the blood to make energy in the cells. Or, it could be that the flow of blood around the body is disrupted.

Betsy Keller, an exercise scientist at Ithaca College in New York, thinks one explanation

FREDERICK FLORIN/AFP VIA GETTY IMAGES

Concentrating for long periods really does drain the brain

When sleep doesn't work

Ordinarily, resting after exertion allows the body to replenish its energy stores within 24 hours. Sleep plays a key role in this.

Although sleepiness and fatigue often overlap, they depend on separate biological processes. Sleep is regulated by the circadian rhythm. This is the body's 24-hour cycle that is controlled by an area of the brain called the hypothalamus, which triggers the release of sleep-promoting hormones including melatonin and adenosine.

"Adenosine is released by cells when their energy supply is compromised," says Craig Heller, a neurobiologist at Stanford University in California. "One of the functions of sleep is to restore the energy reserves of the brain."

For this reason, sleep is the brain's default response to fatigue. However, for reasons that aren't fully understood, in many cases of chronic fatigue, sleep is unable to serve this replenishing role. In fact, a key symptom of ME/CFS is "non-refreshing sleep", meaning people don't feel re-energised if they take a nap or get a good night's sleep.

Some studies suggest that disruption to the activity of the autonomic nervous system may be behind this problem, preventing people from reaching the restorative, deeper stages of sleep. A handful of drugs are being investigated to tackle this, but research is in its early stages. While there are numerous drugs for insomnia on the market, unfortunately none target non-refreshing sleep.

For people who feel fatigued and don't have a chronic condition, the best thing you can do for your body is listen

may involve the brainstem. Ordinarily, a message is sent from the muscles to the brainstem when more oxygen is needed. The brainstem relays that message to the heart and lungs through the autonomic nervous system, which raises heart rate, blood pressure and respiration to increase delivery of oxygen via the blood.

According to Keller, some cases of chronic fatigue could be explained by a problem in the brainstem that results in this message not being communicated properly. Without extra oxygen-rich blood flow, cells can't produce enough energy, so they get fatigued faster and take longer to recover. "Based on what we see clinically, and when you consider how the brainstem impacts blood flow and oxygen delivery to the muscles, they tend to align pretty well; the brainstem is not functioning [properly]," she says.

Another possibility is that there is a problem with the blood itself. Recent studies have found that people with current covid-19 infections, long covid and ME/CFS have higher than average levels of microscopic blood clots, which can block small blood vessels and impede oxygen delivery. One treatment that is being explored to alleviate this in people with long covid is hyperbaric oxygen therapy, in which volunteers breathe pressurised oxygen-rich air while in a hyperbaric chamber. Early results suggest that the treatment reduces fatigue, pain and brain fog.

Another explanation for chronic fatigue is inflammation, the body's first line of defence against injury or infection. Inflammation involves the release of proteins called cytokines that help ready the rest of the immune system for action. Cytokine release is also stimulated by stress to prepare the body for potential injury in times of danger.

> **"Motivation isn't about willpower or desire, it's about the brain managing energy resources"**

The insula in the brain monitors the body's internal state

MYBOXPRA/GETTY IMAGES

Whatever the cause, one of the most notable side effects of all this activity is that it makes you feel lousy: tired, heavy and with a general feeling of "please let me lie on this couch and never move again".

"Cytokines are effective in inducing sleep or fatigue, and it's adaptive," says Craig Heller, a neurobiologist at Stanford University in California. "If you have an infection, you want to decrease the amount of energy you're spending on unnecessary activities."

Brain imaging studies have shown that a surge in cytokines – such as when people are experimentally injected with an immune-stimulating substance or given cytokines as part of a treatment for viral infections – dampens brain activity in the striatum, leading to reduced incentive to move and a general feeling of malaise. Researchers think this is the result of a signal sent to the brain to conserve energy so that all available resources can be used to fight the infection.

"An activated immune system takes up a tremendous amount of energy," says Miller. "The thought of spending any energy to do anything [else] is put into the calculus of what the immune system needs, and the answer that comes out is, 'No, don't have the energy.'"

In an ideal situation, the inflammation – and fatigue – resolve once the body has cleared the infection or the source of stress is removed. But if the inflammation becomes chronic, that malaise can set in for the long haul.

Miller's work has shown that chronic inflammation is common in people with ME/CFS, and that it correlates both with disrupted activity in the striatum and the fatigue that people report. Curiously, his work also suggests that some people with treatment-resistant depression experience similar inflammation and changes to the fatigue network that are seen with both short-lived ailments and chronic fatigue.

It is unclear what triggers the persistent ›

to it and rest when you need. Take a nap; say no to non-essential activities; eat a nutritious meal; go to bed early. And if your symptoms don't resolve in a week or two, talk to your doctor, because fatigue may be telling you something important about your body and brain.

JOSE LUIS PELAEZ INC/GETTY IMAGES

Sleep plays a key role in replenishing the body's energy reserves – if you can reach the deeper stages of sleep inflammation that can occur in depression. For many types of fatigue, though, one idea is an unresolved viral infection.

VanElzakker thinks that in some cases of chronic fatigue, and possibly long covid, the cause is an infection of the vagus nerve. Receptors for this nerve, which provides a direct link from the organs of the body to the brain's insula, are particularly prevalent in places where pathogens enter the body, like the lungs, the oesophagus and the gut. If the vagus nerve becomes inflamed, the insula receives a constant message that there is an infection in the body and energy needs to be conserved.

"An infection on or near the vagus nerve that is driving inflammatory signalling up the vagus nerve is one possibility for non-remitting symptoms," says VanElzakker. "We know from autopsy studies that the vagus nerve can get directly infected [with various pathogens]."

Physical activity runs down the body's cellular energy reserves

DEEPOL BY PLAINPICTURE/SUSSI LORINDER

> **"Energy management involves resisting the urge to push through fatigue"**

Restoring hope

Given the wide range of possible causes, it is good news that a renewed interest in fatigue research, in part inspired by long covid, is providing hope for new treatments. Some of these tackle the root causes of energy depletion while others focus on removing barriers to energy restoration or changing brain activity in some way.

For instance, Miller is attempting to address chronic fatigue in people with either ME/CFS or treatment-resistant depression using anti-inflammatory drugs typically used to treat autoimmune conditions. Importantly, he says this won't work for everyone with fatigue; it is only for the subset of people who have inflammation at the root of their exhaustion. Inflammation becomes the target, he says. "It doesn't matter that you have fatigue and lack of motivation in depression, PTSD, schizophrenia or ME/CFS. If you have inflammation, and it's driving that symptom, the treatment is an anti-inflammatory strategy."

Other research is focused on treating the energy production problem. A clinical trial of an experimental drug that aims to help cells increase oxygen uptake from the blood in people with ME/CFS launched at Brigham and Women's Hospital in Boston earlier this year.

Miller is also investigating the use of drugs like the Parkinson's medication L-DOPA to raise activity in the striatum to nudge the brain's cost-benefit calculation towards action. Another group at the University of California, Los Angeles, is investigating whether targeting the prefrontal cortex using transcranial magnetic stimulation, which influences the brain's electrical activity, may help shift the energy/motivation calculation and relieve fatigue. These treatments are still experimental; only time will tell how effective they are, and for whom.

For people needing help with chronic fatigue now, a common treatment option is energy management, or pacing, which involves continuously monitoring how they feel and resisting the urge to push through their fatigue. Similarly, cognitive behavioural therapy can help some people cope with the limitations of their condition.

These strategies can be particularly helpful for people who lived an active life before their diagnosis. Lisa Clock, a former collegiate athlete in Georgia who developed ME/CFS after a viral infection in her 20s, learned these lessons the hard way. When fatigue first started to affect her life, she tried to draw on her experiences as an athlete.

"I learned in sports that you push through pain, and you create endurance by working and pushing yourself in a strategic way," she says. "And every time I'd say, 'OK, I'm going to do that. I'm going to push through,' I would end up flat on my back with swollen glands and [it was] hard to move. It worked completely in reverse to how it had always been for me."

Instead, to manage her symptoms, Clock has learned to pay attention to her energy levels and work in spurts when she feels better, often while lying down on the floor.

She is now being treated by Miller with drugs that target some of the possible causes of her fatigue. So far, she has tried L-DOPA, IV fluids with electrolytes and even ketamine, an experimental treatment for depression that boosts activity in the prefrontal cortex. Now she is on the immune-suppressing drug rapamycin to target inflammation. Some treatments work better than others, and she hasn't found a cure yet, but she says she has to keep trying. "You get one life, and I don't want to miss my own life, but it feels like a lot of times I am," she says. "I have to keep trying. I don't want to miss everything." ∎

You should consult your doctor before starting medical treatment.

Dana G. Smith is a science journalist based in Durham, North California

NABIL NEZZAR

The Pope's AI adviser

Franciscan monk **Paolo Benanti** is leading a global call for artificial intelligence developers to respect human dignity. He tells Charlotte Lytton how it is going

PAOLO BENANTI wakes early in the monastery in Rome where he lives to begin each day in prayer. So far, so conventional – for a monk. But outside of the monastery, Benanti's life is less typical. He trained as an engineer and ethicist, and he now spends his time at the nearby Pontifical Gregorian University, where he teaches the ethics of artificial intelligence. He also frequently walks over to visit Pope Francis himself, to whom he has become a trusted adviser on AI.

This has become an important topic for the pontiff because he fears it could adversely affect the most vulnerable members of society, and increase the world's already stark inequality. To fight against this, Benanti helped draft the Rome Call, a commitment, signed in March 2020 by global tech firms IBM and Microsoft, that human dignity will always be a priority as AI is rolled out worldwide. With an expanded version of the pact now in the works, *New Scientist* spoke with Benanti about the role of religions in the control of technology, if an AI apocalypse is on the cards and whether an algorithm could ever replace God.

Charlotte Lytton: Why did you become a monk?
Paolo Benanti: When I finished high school, I went to study engineering at university. But in the last year, before I got my degree, I decided to change my life and I joined the [Franciscan] order. I'm curious about human nature, what it means to be human, and I was looking to understand reality. I realised that engineering was a good way to approximate reality, but I was starting to look for something more. At that point, I met the Franciscan community and got the feeling that this was where I was meant to be. It offered me life in a fraternity,

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the opportunity to share and meet people, and the ability to study and search for the meaning of things that had long fascinated me.

What is an average day like for you now?

I live in a really old monastery with four other monks. We wake up in the morning, usually early, and pray together for 45 minutes or an hour. Then, at 7:30am, normal life begins. Everyone has their own jobs – mine is to teach at the university and study. We have communal lunch and dinner, and there are five moments of prayer during the day.

When did your interest in AI begin?

In 2009, after I joined the order, I began a seven-year PhD studying technology and ethics – the idea was to bring together these two worlds. When I started, I felt the most promising technological developments in the next decade or so would be in neurotechnology and nanotechnology. But as time went on, I got the deep sense that AI would be the next big thing.

How did you come to be advising Pope Francis, and how much does he know about AI?

It all started when I spoke at a seminar for Roman Curia personnel, the department that helps the pontiff carry out his day-to-day work. I can't say too much more about the process.

Can the Pope understand every time we talk about machine learning or algorithms? Probably not. But what he understands very well is the condition of humans around the world. If you tell him that the fate of a migrant or asylum seeker will be judged solely by a machine, he understands what that means. He's much more active on the value side of the discussion, as opposed to technology and complicated maths.

What are your fears about how AI will shape our future?

Maybe some people think it will be like the apocalypse in the *Terminator* films. But we should actually be scared by another apocalyptic scenario: the end of the middle class. It's much, much easier to have an AI act as a surrogate for an accountant than for a blue-collar worker like a plumber or a builder. This means we could have a future in which the majority of people will have low-paid jobs, with the rest taken by machines. That inequality could be really dangerous. The gap created between poor and rich could lead to general conflicts, radical societal transformations and other unknown fallouts.

Are you worried about that future coming to pass?

Well, I see there is huge public opposition to that idea. For instance, in 2021, the United Nations Educational, Scientific and Cultural Organization (UNESCO) set out its Recommendation on the Ethics of Artificial Intelligence, signed by its member states. This ensures that regulations will be put in place to create human-centred AI, so that emerging technologies benefit the population. That major bodies are working on regulations like this makes me a little bit confident that we can handle the challenge.

Tell us about the Rome Call and how it came to be.

I've been privy to a lot of panels, not only with governments or academics, but also where technology partners were present. I started discussions with lots of people in different companies. I remember sitting in a coffee break at the end of a panel, and I said: "Wouldn't it be wonderful if we could more effectively realise the common desire to protect humans with an international call to action?"

I started to open a channel with my contacts in that area. IBM and Microsoft were the first involved. We drafted a list of principles that tried to describe how AI could be developed responsibly – in a way that would respect humans. The principles were transparency, inclusion, accountability, impartiality, reliability, security and privacy. These ideas are connected to a new word that the Pope has used a couple of times: algorethics.

A hundred years ago, John Fletcher Moulton, the mathematician, judge and politician, wrote about the "obedience to the unenforceable". These are the unwritten ethical standards we hold ourselves to, like when the Titanic was sinking and people urged women and children to get on boats first. Such ethics aren't written down anywhere and it is not easy to turn these rules into an algorithm. I like to think of these unwritten ethics as the quality of gentleness, and I think machines have to have this quality. That's why, with the Rome Call, we are trying to encourage companies to shape algorithms to be gentle in the human-machine relationship.

What does the Pope think of the Rome Call?

That it was a really big thing. He is very much behind the Holy See [the government of the Catholic church] being a facilitator for governments, companies and other international institutions to find an agreement

NEALE CLARK/ROBERTHARDING/ALAMY

Saint Peter's Square in Vatican City, where the ethics of AI are taking centre stage

"We wake up early and pray for 45 minutes. Then, at 7:30am, normal life begins"

> "I like to think of our unwritten ethical rules as gentleness – and machines have to have that quality"

on ethical guardrails for AI. For him, it's crucial that it won't harm the young generation or the elderly – especially in the wake of the pandemic, in which the importance of our digital lives has exploded.

How can we tell if it is working?
I have to say, something is working. Remember, the Rome Call is just that: it's a call to action. That means everyone who says it's important is accountable to themselves to make it workable. This was a cultural moment, and it was a moment in which people with the same sensibility about how dangerous AI could be if not aligned with human values came together. Universities that signed the Rome Call are starting to teach the ethics of AI in their engineering programmes. Journalistic institutions are starting to shape themselves to make the Rome Call effective. Tech companies are developing processes that make algorethics effective in their production processes.

We have a huge event in October with many senior signatories, and in which we will say how algorethics could be included in a lot of new software production processes. How fast and effective it will be depends on how many are involved.

AGENZIA ROMANO SICILIANI/S

Paolo Benanti speaking at the signing of the Rome Call in March 2020. Behind him are Brad Smith of Microsoft; John Kelly, then of IBM; David Sassoli, then president of the European Parliament; and Qu Dongyu, director-general of the UN's Food and Agriculture Organization

Can we really expect companies to care about ethics over profit?
We cannot ask companies not to think about business. But I have seen in the past five years that – slowly, slowly – they are starting to think about their purpose. Some of them are allowing employees to undertake social purpose projects. I know some who allow 10 to 15 per cent of employees' working hours to be used for this kind of thing, like digital tools to recognise cyberbullying or pictures of abused children in pornography. Companies are moving gradually from being shareholders to stakeholders. From my perspective, it's a good sign.

There has been talk of a version of the Rome Call backed by other faiths too. When will that come into effect?
We intended to sign the call in May in Abu Dhabi, with Muslim and Jewish signatories. But the president of the United Arab Emirates, Sheikh Khalifa bin Zayed Al Nahyan, died in May. To allow the nation a period of mourning, we have had to delay. The agreement is ready, we now need to find a workable date for the signing. It's not easy, with three different religions in which everyone has their own calendar.

Governments are struggling to regulate technology. Do religious institutions stand a better chance?
The majority of people in the world belong to monotheistic religions, so the religious perspective is powerful. The role for religious organisations is to help guide governments. Religions gather human wisdom and timeless values, which, if shared in a non-religious setting, can facilitate dialogue and social awareness. This is what the Rome Call is trying to do, to capture the public opinion that technology should be used ethically.

How might AI be used for good?
Some of my PhD students are looking at this now, researching how healthcare could be transformed by the digital revolution and help to cure disease. Digital tools like AI and the cloud could be used for the global good of humanity. We were able to get vaccinations early and effectively thanks to the compilation of data shared on the cloud. My huge hope is that humankind can find new ways to protect other humans and to use AI for the global good.

A Google engineer recently described the company's chatbot, which he had been testing, as sentient. What did you make of that?
LaMDA 2.0 was a product designed to guess what the user wanted to hear. This powerful algorithm was able to see that the man sitting in front of it desired to find someone behind the screen. And so what he saw was a mirage in the desert – the powerful tools we have developed fooled one of our technicians with the quality of its answers. Academics are absolutely sure there is no sentient AI.

Can an algorithm ever replace God?
That's delusional. If God is the source of life, the one who can give us the meaning of life, that is something that is beyond us. If we start to give undue praise to something below us or made by us, then, in the biblical tradition, that has a really clear name: an idol. ■

Charlotte Lytton is a freelance journalist based in London

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Stargazing at home

Hide and seek with Uranus

You can watch this planet pass behind the moon and emerge on the other side in a rare event this month, says **Abigail Beall**

Abigail Beall is a feature editor at *New Scientist* and author of *The Art of Urban Astronomy* @abbybeall

What you need

Binoculars or a telescope
Dark skies
Software like Stellarium (optional)

ON 14 September, stargazers will be treated to a lunar occultation of Uranus. In this rare event, the planet will pass behind the moon in the sky, with the moon temporarily blocking Uranus from view. Around an hour later, it will re-emerge on the moon's other side.

Because the moon is so close to Earth compared with everything else we see in the night sky, it appears at different points, relative to the stars and planets, depending on where you look from. This means that lunar occultations, where the moon appears to move in front of a planet, are only visible from certain parts of the world. This occultation will be visible in Europe, north Africa and north-west Asia.

To find out exactly when you need to look, it is best to use software such as Stellarium to check what the night sky will look like where you are on the evening of 14 September. From the UK, the occultation will be visible at around 10.30pm, but you should start looking at around 10.15pm. Uranus will reappear on the other side of the moon just before 11.30pm.

To see this event, you will need a dark sky away from light pollution and a pair of binoculars. Look for a small, fuzzy dot of light to the left of the moon as you are looking at it, next to the moon's sunlit part, which will be 80 per cent visible.

BABAK TAFRESHI/SCIENCE PHOTO LIBRARY/NASA

Through binoculars, the little dot might appear greeny-blue and look more like a disc than a point of light. Then just sit back for the next hour and watch as Uranus passes behind the moon, then pops out again on the moon's unlit side.

Uranus is the seventh planet from the sun, and it is sometimes visible with the naked eye from places that are dark enough. But to guarantee you will see it passing behind the moon, use a pair of binoculars.

Uranus and Neptune both appear blue because of methane in their atmospheres, but Uranus has a hazy layer that looks white-ish, dulling its colour compared with the brighter Neptune. Both are ice giants, but Neptune, being much further away, is never visible with the naked eye.

If you don't get clear skies this time around, don't worry. There will be another chance for those in western Europe to catch a lunar occultation of Uranus on 5 December. If you aren't in that part of the world, you might get your chance when, on 12 October, another lunar occultation of Uranus will be visible from much of the US, Canada and Greenland, or again on 8 November, when it will be seen from much of east Asia and Alaska.

If you are based in Australia or New Zealand, unfortunately you won't see an occultation this year. But in 2023, parts of Australia will be treated to a total solar eclipse, so it isn't all bad. ▮

Stargazing at home appears every four weeks

Next week

Science of gardening

These articles are posted each week at newscientist.com/maker

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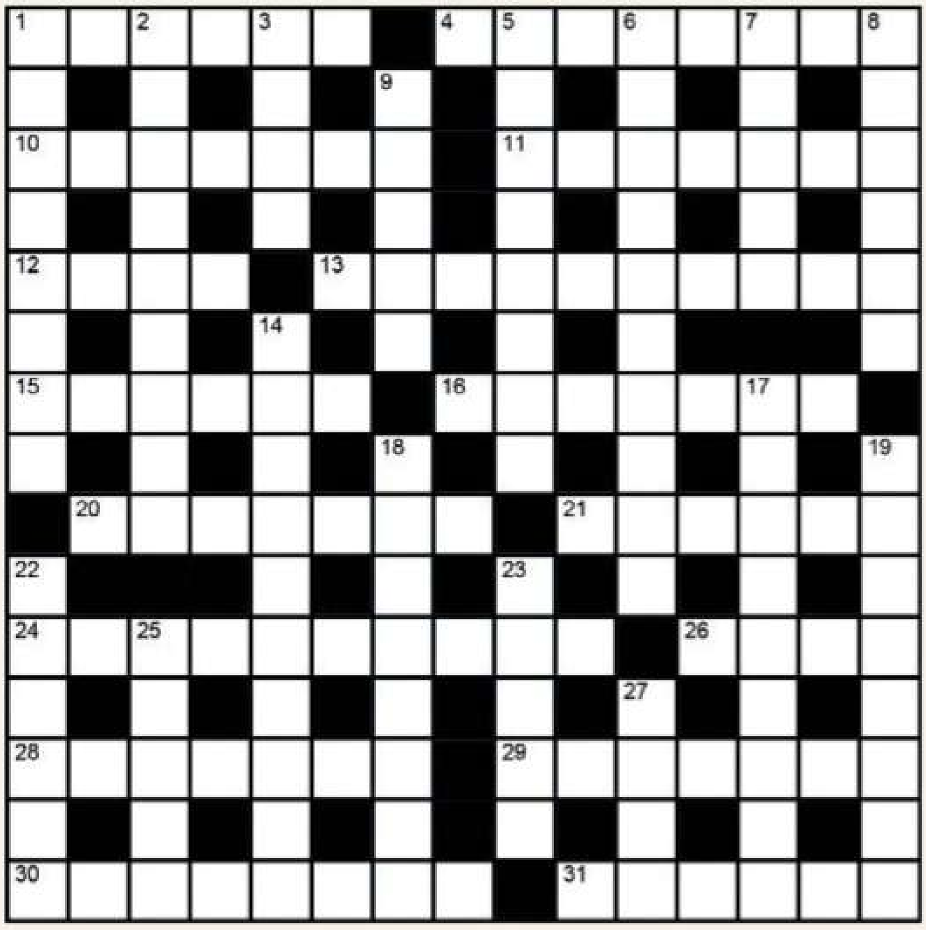
Quick crossword #116 *Set by Richard Smyth*



Scribble zone

Answers and the next cryptic crossword next week

ACROSS

1 Doe, pen or sow, perhaps (6)
4 Bulge in a blood vessel (8)
10 Fatty (7)
11 Type of bitumen deposit (3,4)
12 Rotator ____, group of shoulder muscles (4)
13 Robots (10)
15 Ice giant discovered in 1781 (6)
16 Ice giant discovered in 1846 (7)
20 Of a computer, not portable (7)
21 Probability of use in qualitative testing (1-5)
24 The study of the years ahead (10)
26 A trading name of ExxonMobil (4)
28 Mountain 8848.86 metres in height (7)
29 Common ingredient of fertilisers and explosives (7)
30 Sci-fi comic character created by Alan Martin and Jamie Hewlett (4,4)
31 Ball (6)

DOWN

1 Fr (8)
2 Large computer, typically used for data processing (9)
3 Ring road; rollercoaster component (4)
5 N (8)
6 Inert (10)
7 Mature form of an insect (5)
8 Jellyfish life stage (6)
9 Second planet from the sun (5)
14 Mark ____, Facebook co-founder (10)
17 Kernel of a linear map, in mathematics (4-5)
18 One who arranges or combines texts (8)
19 Paraffin (8)
22 It follows a cause (6)
23 Active substance; autonomous individual (5)
25 Alien in the Dan Dare stories (5)
27 Tread or riser (4)

Our crosswords are now solvable online
newscientist.com/crosswords

Quick quiz #168

1 In mathematics, the numbers 8, 17, 32, 54, 57 and 100 are the first six of which type of number?

2 In what year did Howard Carter's archaeological expedition find the entrance to Tutankhamun's tomb?

3 Which of these elements is an actinide: thulium, fermium or samarium?

4 Who was the inventor of the mass spectrograph?

5 How many living species of the *Panthera* genus are there?

Answers on page 55

Puzzle

set by Rob Eastaway

#184 Cipher sum

The sum shown below appears to be nothing out of the ordinary. The figures add up correctly as you would expect. But it has a rather unusual property. This is a cipher sum. Each of the digits represents a different digit, with the same digit always representing the same alternative digit.

The sum that it represents also adds up correctly. Can you find it?

  26374
+ 46462
  72836

Solution next week

Hole number

My microwave meal says remove sleeve and pierce film. What is the optimal number of holes I should make?

Bob Magee
Cardiff, UK
The optimum number is one. The holes are to allow hot air and steam to escape, so the film seal doesn't "pop" and spray food over the inside of your oven. An excessive number of holes will weaken the film and it might tear when being peeled back.

Having said that, I always use a fork, which makes four holes, because forks are conveniently to hand and make circular holes rather than slits, which would be potential tear points.

> "One hole in the film of a microwave meal will remove the risk of pressure build-up, but it is impossible to resist making more"

@Roger120M
via Twitter
One puncture will remove the risk of pressure build-up, but making the holes sounds so good and is so satisfying that is impossible to do this less than five times.

MAURICE SAVAGE/ALAMY

Will we ever run out of variations of QR codes and need to recycle them?

This week's new questions

Code limits **Are there limitless permutations of QR codes or are they recycled after a prescribed length of time?**
***Bonita Ely**, Sydney, Australia*

Joe average **Who is the average person in the world, and what is their age, location, physical appearance etc?**
***Rachel Peynado**, Ashton-under-Lyne, Greater Manchester, UK*

Peak spot

The highest peaks in each of the five countries of the British Isles are all within around 15 kilometres of the coast. Is there any geological reason why they are all so close to the sea?

Hillary Shaw
Newport, Shropshire, UK
Two factors may apply here: geometry and geology.

Geometrically, a significant fraction of Britain is within 15 kilometres of the sea. England, its biggest country, approximates to a 500-kilometre x 200-kilometre rectangle (minus Devon and Cornwall). This means that 485km x 170km of it (allowing for the landlocked north border), or around 17.5 per cent of the land, is within 15km of the sea. Similar calculations show that around 23.5 per cent of Ireland is less than 15km from the coast.

Indented coastlines, common in the British Isles, increase this percentage, so a random location in England has a better than 18 per cent chance of being within 15km of seawater, and one in Ireland has a better than 24 per cent chance.

Then we have geology. Peaks that are higher than everything in the landscape have probably been geologically uplifted recently. Uplifts are often associated with a lowered "syncline" region close by, where Earth's crust has been forced downwards. In an island country, that syncline may well be under the sea.

David Jarman
Ross-shire, UK
Although four of the five tallest mountains of the British Isles are formed primarily of igneous rock, it isn't the rock type but tectonics that makes them all close to the coast. The coastline has fluctuated wildly over time and these mountains were once located much further from the sea.

Tectonic events created the bodies of water that are now close to them. The fact that the highest mountains of Scotland, Wales and England are all near the west coast is probably due to a continental collision that took place around 300 million years ago called the Variscan Orogeny. This directly affected only southern areas of the landmass of Britain-Ireland, giving us the MacGillycuddy's Reeks mountain range in Ireland and the Brecon Beacons in Wales.

However, the aftermath of that collision provoked a rift zigzagging up through the landmass of Britain-Ireland, opening basins such as the Irish Sea, plus the Firth of Clyde and the Sea of the Hebrides on the west coast of Scotland. This meant that the spine of mountains and hills running down the island of Britain, which had been fairly central when Britain-Ireland was created, now became west-centred.

Thus, Ben Nevis, Scotland's tallest mountain, is now a stone's throw from seawater in Loch Linnhe. England's highest peak, Scafell Pike, and Snowdon in Wales are both close to the Irish Sea.

Also, bear in mind that around 60 million years ago, a chain of volcanoes that we now know as the islands of Skye, Mull and Arran, off the west of Scotland, would briefly have dwarfed today's highest peaks.

No joke

Do any other animals have a sense of humour? If you slipped on a banana skin, are there any creatures that would laugh? (continued)

Mike Follows
Sutton Coldfield, West Midlands, UK
The great apes appear to laugh, suggesting that laughter originated in a common ancestor. A quick internet search, for instance, shows an orangutan that seems to laugh at a conjuring trick. A captive gorilla called Koko was taught to communicate with more than 1000 words, using a modified sign language. Apparently, she tied her trainer's shoelaces together before signing "chase" and making laughing noises at the result.

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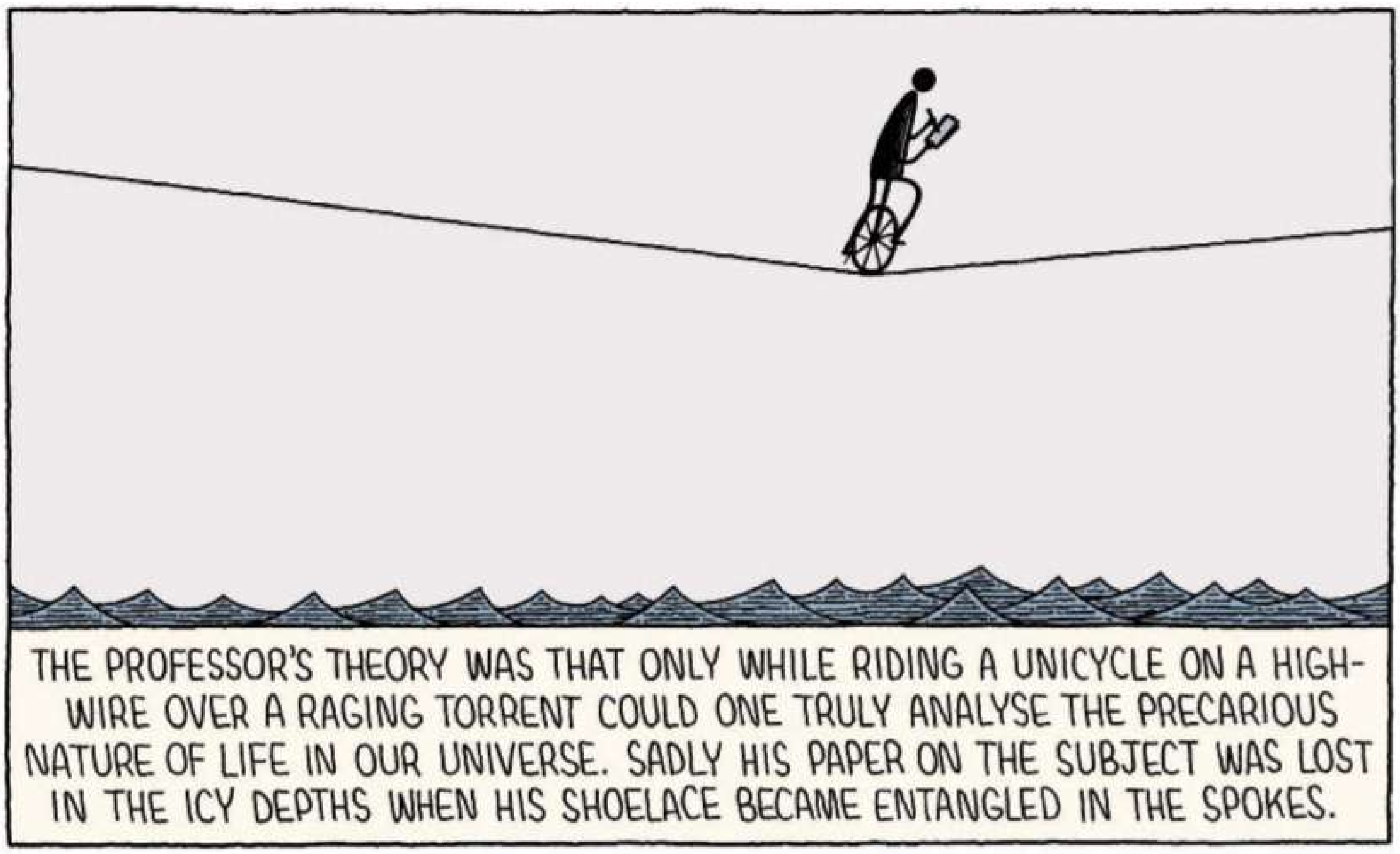
Tom Gauld

for New Scientist


THE PROFESSOR'S THEORY WAS THAT ONLY WHILE RIDING A UNICYCLE ON A HIGH-WIRE OVER A RAGING TORRENT COULD ONE TRULY ANALYSE THE PRECARIOUS NATURE OF LIFE IN OUR UNIVERSE. SADLY HIS PAPER ON THE SUBJECT WAS LOST IN THE ICY DEPTHS WHEN HIS SHOELACE BECAME ENTANGLED IN THE SPOKES.

It is difficult to recognise laughter in other species, so the roll call could be much higher than the 65 species noted by researchers to make laughing noises during play, which range from foxes to orcas and birds. After all, chimpanzee laughter can easily be mistaken for screeching. Rats enjoy being tickled, but the giggles they emit are ultrasonic. Dolphins produce different sounds when larking about than they do when hunting and we assume it is to express pleasure, if not laughter.

Play fights are important among some species, for bonding and for learning how to hunt. Animals "attacked" during play fights make vocalisations that can be interpreted as laughing. Peter McGraw at the University of Colorado has suggested that laughter evolved to signal that something normally perceived as aggressive is acceptable.

However, we need to avoid anthropomorphising. After all, dolphins look as if they are perpetually happy, but this surely cannot be true. In humans, laughter is quite nuanced. Sometimes it can be to signal that you belong to the in-group. It can also be used to ridicule someone, so it can have a dark side.

> **"It is difficult to recognise laughter in other species. Rats enjoy being tickled, but the giggles they emit are ultrasonic"**

Geoffrey Swenson
Bonney Lake, Washington, US

I once experienced a parrot with a profound sense of humour. The owner steered the conversation to some extent, but then the bird took over. It started telling one-liners, and as we talked about the jokes, the bird picked up on the context and spouted off more jokes with perfect comedic timing and laughed at them with us.

It seemed like the parrot wasn't merely saying things, it appeared to understand what we were saying and its own replies, as so many of the jokes were in perfect context with our conversation.

Kathryn Smits
Auckland, New Zealand

Some decades ago, there was a colony of myna birds nesting in a tree by our house. Our cat may have climbed up and hurt young birds, so what follows may have been an act of revenge. It was carried out systematically and with considerable glee.

I watched as my cat was lured away by a pair of mynas, quite playfully at first. Dramatically fluttering, they convinced her to follow them to the limb of a tree about 2 metres above the lawn. Once she was up there, quite exposed, they attacked. They pecked her head and bottom until she lost her balance and tumbled. The birds cackled and took off.

What fascinated me was the mirth, the sheer exuberance and intelligence of it all, as well as the cackling laughter. It convinced me that mynas have a sense of humour and probably a sense of justice as well. ▮

Answers

Quick quiz #168
Answers

1 Leyland numbers, which can be expressed as $x^y + y^x$ where x and y are integers greater than 1
2 1922
3 Fermium
4 Francis Aston
5 Five

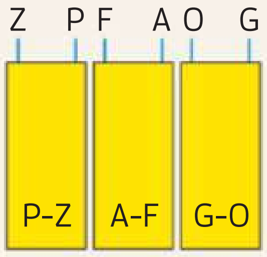
Cryptic crossword #91 *Answers*

ACROSS 1 Pelagic, **5** Ropes, **8** Sabrewing, **9** Lox, **10** Atlas, **12** Aplasia, **13** James Lovelock, **15** Galileo, **17** Offal, **19** Log, **20** Chidingly, **22** Ratel, **23** Tanager

DOWN 1 Pasta, **2** Lab, **3** Greases, **4** Climatologist, **5** Regal, **6** Polish off, **7** Six-pack, **11** Limelight, **13** Jugular, **14** Emotion, **16** Local, **18** Layer, **21** Gag

#183 Animal rights
Solution

The books are arranged in this order:



The catch (that most people miss) is that the first page in any book is on the right as you look at the spine of the book, while the last page is on the left. If you need convincing, take a book off your shelf, bookmark the first page and put it back on the shelf.

Outside in

After scientists came up with a way to partially unboil an egg, seven years ago, researchers have now cooked up a solution to a superficially similar challenge: how to boil an egg so that the yolk winds up on the outside of the inside.

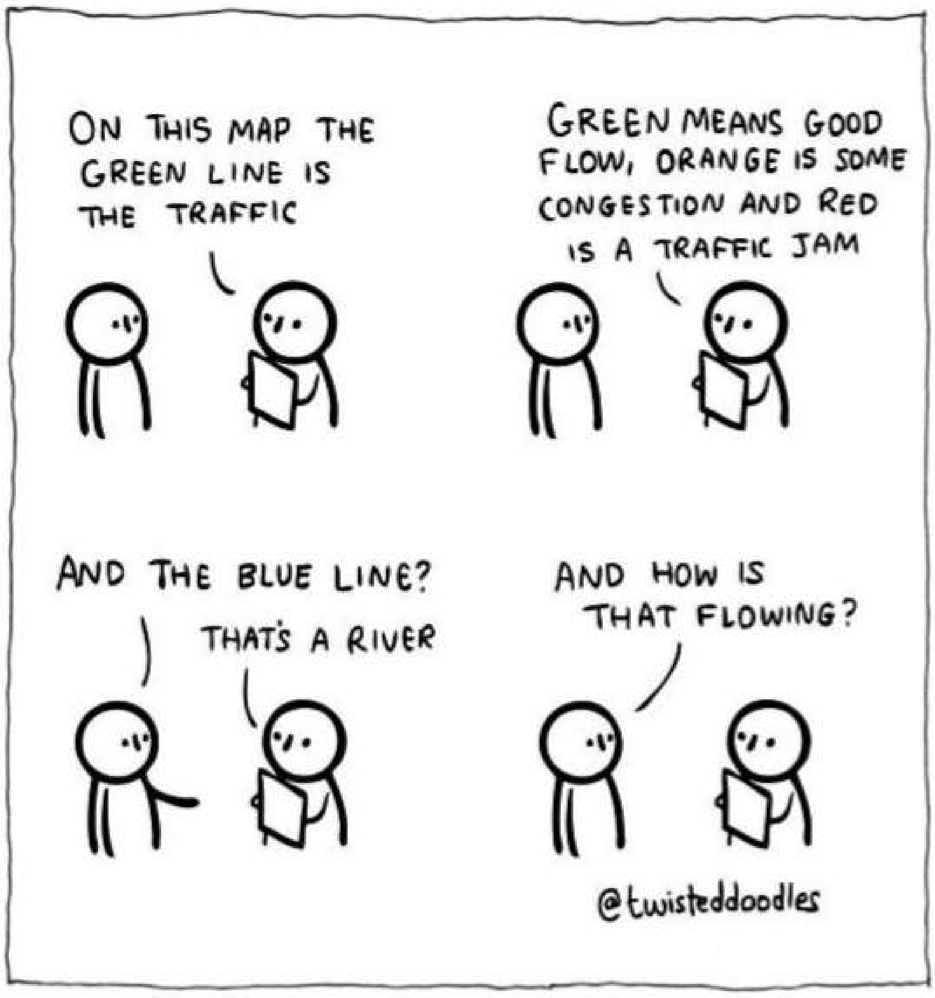
The partial unboiling was revealed in the journal *ChemBioChem* in 2015. The scientists used a centrifuge-like device to spin a clump of folded (or, depending on one's point of view, misfolded) proteins. This proved to be a quick, inexpensive way to get some of those proteins to re-fold themselves – to revert their boiled molecular shapes back into earlier, pre-boiling configurations.

Rather different is the way Hajime Hatta, Ayami Nakamoto and Yasumi Horimoto say they solved a more-than-two-centuries-old egg-inversal mystery. They reveal their method in a paper titled "Reproduction of a Reversed Boiled Egg (the Yolk Inside Out) Listed in an Old Japanese Recipe Book".

The study explains that the cookbook includes 103 egg recipes, of which only the reversed boiled egg has never been reproduced. "The key to solving the mystery," write the researchers, "lay in the idea that the eggs used for cooking in such an old period could be mostly fertilized eggs. We finally reproduced the reversed boiled egg by using fertilized eggs incubated for three days at 38 degrees C."

The secret, they say, is that in unfertilised eggs, the yolk is thick and sticky, while the egg white is runny. But with a fertilised egg, the reverse is true: the yolk is watery and runny, while the white is thick and sticky. So the yolk can ooze outside the confines of the white.

Twisteddoodles *for New Scientist*


ON THIS MAP THE GREEN LINE IS THE TRAFFIC
GREEN MEANS GOOD FLOW, ORANGE IS SOME CONGESTION AND RED IS A TRAFFIC JAM
AND THE BLUE LINE?
THAT'S A RIVER
AND HOW IS THAT FLOWING?
@twisteddoodles

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Consideration of items sent in the post will be delayed

Up with eggs

Cultural historian Alison Vincent, meanwhile, pursued her own, no-cooking-involved vision of what can, but maybe should not, be done with eggs, preparing a partial history of when, why and how eggs have been tossed at politicians. In a paper presented at the Dublin Gastronomy Symposium in 2020, she says: "Practically eggs are easy to acquire, in that they are relatively cheap and readily available, easy to conceal and easy to transport, taking care that they do not break before required."

Vincent took care that her paper not be overly egg-centric. The reader is advised that "another not uncommon projectile used in similar circumstances is the pie".

The egg man

Eggs have gone largely unmentioned in the mudslings and rhetorical arrows about Brexitannia being potentially cut off from reliable access to foreign food sources. It is cheering to learn how hard Hugh Cott worked to solve similar worries in the mid-20th century. A zoologist at the University of Cambridge, Cott oversaw a project to sample the many kinds of bird eggs laid in Britain (and a few laid elsewhere). The goal: to ascertain which would be edible, or at least palatable, should the worse come to the worst in a time of dwindling food supplies.

Cott published a series of thick reports in the *Proceedings of the Zoological Society of London*. The titles are a fair summary, from "The Palatability of the Eggs Of Birds – Illustrated by Experiments on the Food Preferences of the Hedgehog" via "The Palatability of the Eggs of Birds: Illustrated by Three Seasons' Experiments (1947, 1948 and 1950) on the Food Preferences of the Rat" to "The Palatability of the Eggs of Birds: Mainly Based Upon Observations of an Egg Panel".

They make for delicious reading. For the egg panel, "samples were tested in the form of a scramble, prepared over a steam-bath, without any addition of fat or condiment". Each taster assessed each sample on a scale dropping from "ideal" down to "repulsive and inedible". The paper concludes with a list of the different egg types "in descending order of acceptability".

At the top was chicken, then emu, coot and black-backed gull. The eggs of last resort, as rated by official British egg-tasting persons: green woodpecker, Verreaux's eagle owl, wren, speckled mousebird and, dead last, black tit.

Tadpole tastings

Cott was also addressing the question of why the most conspicuous eggs taste terrible to whatever might want to eat them. Ditto the kinds of birds that were strikingly easy for predators to spot. Phrased starkly: Why have gaudy critters not been long ago gobbled up and become extinct? The answer: the flashy ones usually taste terrible.

Enamoured of tadpoles, and inspired by Cott's feasts, biologist Richard Wassersug loosed a panel of graduate students on the issue. His study, "On the Comparative Palatability of Some Dry-Season Tadpoles from Costa Rica", published in the journal *The American Naturalist* in 1971, describes what happened:

"The tasters were asked to rate the palatability of each tadpole's skin, tail, and body on a 1 to 5 scale… A tadpole was rinsed in fresh water. The taster placed the tadpole into his or her mouth, and held it for 10-20 seconds without biting into it. Then the taster bit into the tail, breaking the skin and chewed lightly for 10-20 seconds. For the last 10-20 seconds the taster bit firmly and fully into the body of the tadpole. The participants were directed not to swallow the tadpoles but to spit them out and to rinse their mouths out at least twice with fresh water before proceeding."

The results pretty much confirmed the idea that the more conspicuous the tadpole, the less palatable it is likely to be. ▮

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